Original Article

Mode of correction is related to treatment timing in Class II patients treated with the mandibular advancement locking unit (MALU) appliance

Muhsin Candir[a]; Heidi Kerosuo[b]

ABSTRACT

Objective: To investigate the proportion of skeletal/dentoalveolar components for correction of Class II malocclusion in relation to the pubertal growth peak (PGP) among patients treated with the mandibular advancement locking unit (MALU) appliance.

Materials and Methods: We conducted a retrospective study of 27 orthodontic patients (age range: 12–18 years; mean age 14.9 years) with skeletal Class II Division 1 malocclusion who were treated with the MALU appliance until they reached Class I occlusion with overjet and overbite within normal range. Pretreatment (T1) and posttreatment (T2) lateral cephalograms were analyzed using standard cephalometrics and sagittal occlusion analysis to assess changes in the dentoalveolar and skeletal complex. The cervical vertebral maturation (CVM) method was used to determine participants' skeletal maturation in T1 cephalograms. Based on this maturation, participants were divided into two groups: the peak group (treatment initiation before or during PGP [peak group, n=15]) or the postpeak group (treatment initiation after the PGP [n = 12]).

Results: No significant differences between groups were found at T1 for most of the skeletal and dental parameters investigated. At T2, the mean ANB angle and proclination of the mandibular incisors were significantly smaller in the peak group than in the postpeak group. In the peak group, skeletal correction comprised 54% and dental correction 46% of the total change at T2, while in the postpeak group the corresponding figures were 24% and 76%, respectively.

Conclusions: Treatment initiated before or during PGP seems to result in a more favorable SNA/SNB relationship and less tipping of the mandibular incisors than when treatment is initiated after PGP. (*Angle Orthod.* 2017;87:363–370)

KEY WORDS: Cephalometrics; Class II; Fixed functional appliance; MALU; Treatment timing

INTRODUCTION

Treatment with functional appliances among patients with skeletal Class II malocclusion aims to bring the mandible into a more forwarded position in relation to the maxilla.[1–4] At the beginning of the 19th century, the Herbst appliance was introduced as the first fixed bite-jumping device that kept the mandible in a continuously protruded therapeutic position.[2,5] Studies by Pancherz and colleagues have shown that patients treated with the Herbst appliance that go from Class II to Class I show a change in molar relationship that has both dentoalveolar and skeletal components.[1,2,5] Limited skeletal changes have also been recently reported among patients treated with the Herbst appliance after they had passed their pubertal growth peak (PGP).[2,3,5,6]

The PGP is generally considered the most favorable time for using functional appliances in Class II patients, and skeletal treatment effects have been most pronounced in the circumpubertal stage.[7,8] However, there is great variation in the timing of the PGP among individuals. Different methods have been developed to evaluate the start of PGP, but the hand-wrist radiograph and the cervical vertebral maturation (CVM) method are the most common.[9–11] The CVM method is based on changes in the shape of cervical vertebrae and skeletal maturation during growth, which can be assessed on a standard cephalogram without additional exposure to radiation. In a recent systematic review, a moderate-to-high, statistically significant correlation was shown between the CVM and hand-

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Figure 1. MALU appliance.

wrist maturation methods. A moderate-to-high reproducibility of the CVM method was reported.[12]

Since the introduction of the Herbst appliance, several other variations of fixed functional appliances have been produced. The few reports have shown that these appliances render treatment effects similar to those of the Herbst appliance.[13,14] One of these appliances is the mandibular advancement locking unit (MALU) appliance (Saga Dental Supply AS, Kongsvinger, Norway). The MALU appliance is a telescopic, rigid, fixed functional appliance that is integrated into an existing edgewise appliance (Figure 1). Unlike the Herbst appliance, which is prepared in the dental laboratory, the MALU is prepared chairside, saving time and treatment cost, which may have contributed to its common use in Norway. However, except for a few case reports, evidence on the mode of correction in Class II patients treated with the MALU appliance is lacking, especially regarding eventual skeletal effects.[15,16] Thus, the aim of this study was to investigate the proportion of skeletal/dentoalveolar components for correction of Class II occlusion in relation to the PGP among patients treated with the MALU appliance. The null hypothesis was that there is no difference in the mode of Class II correction (skeletal/ dentoalveolar) between patients showing different skeletal maturation stages at the start of treatment.

MATERIALS AND METHODS

All orthodontic patients with skeletal Class II Division 1 malocclusion who had completed treatment with the MALU appliance (SAGA Dental Supply AS, Kongsvinger, Norway) between January 2009 and December 2011 in the orthodontic clinic at the Public Dental Service Competence Centre of Northern Norway (TkNN) were eligible for the present retrospective study. To be included, individuals had to have good quality pretreatment (T1) and posttreatment (T2) lateral cephalograms, and they had to fulfill the following occlusal and dental criteria at T1: full Class II or end-on Class II molar relationship uni- or bilaterally; overjet larger than 5 mm; ANB angle larger than 5°; permanent dentition; aligned or mildly crowded (less than 3 mm) mandibular incisors; and no permanent teeth extracted. Thirty patients fulfilled the inclusion criteria during the given time period, but three were excluded due to incomplete treatment, leaving a total of 27 participants (11 males, 16 females). Their mean age was 14.9 years (range, 12.2–18.7 years), 15.0 (SD 1.74) and 14.9 (SD 2.07) years for males and females, respectively.

All participants received the same treatment: the maxillary and mandibular molars and the mandibular canines were banded. The mandibular incisors and the first premolars were bonded with 0.022-inch MALU single brackets having 0° torque and a 0.021 × 0.025-inch stainless steel arch wire, consistently cinched to the molars, was placed. The MALU tube-and-plunger assembly was adjusted to the amount of mandibular protrusion needed and attached from the headgear tube to the mandibular key hinge distal to the mandibular canines. Quick initial alignment and leveling of the mandibular incisors was done, if considered necessary to place a 0.021 × 0.025-inch stainless steel arch wire before starting with the MALU appliance. No alignment of the maxillary incisors was needed. The MALU treatment was started with a single, full activation and was continued until a Class I molar and canine relationship, or slightly overcorrected, was reached. Patients attended regular check-ups every fourth week. To keep the midlines on, the plungers could be reactivated with spacers. Following the clinical guidelines for the MALU, we set the minimum treatment time to 6 months, varying from 6 to 9 months. Most T1 cephalograms were obtained immediately before placement of the MALU appliance, and the posttreatment (T2) cephalograms were taken after completion of the mandibular advancement with the MALU appliance. In none of the subjects did the time from the T1 cephalogram to treatment start with MALU

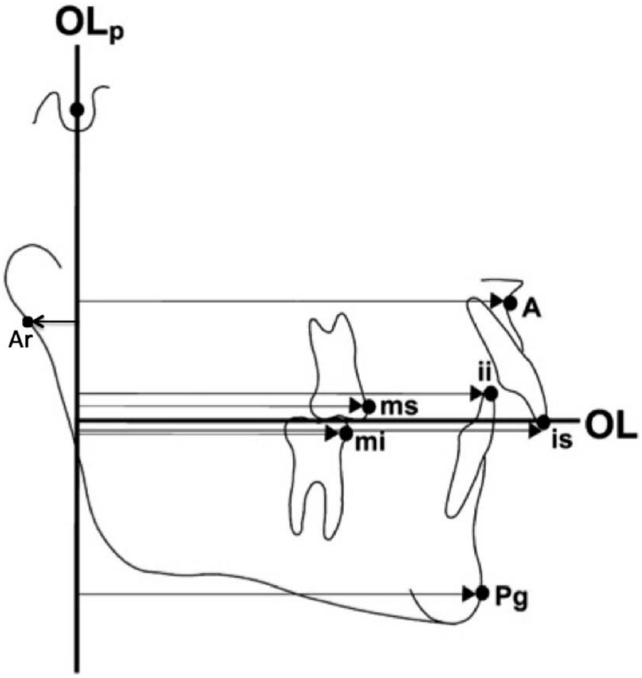

Figure 2. Sagittal occlusion analysis.[17]

exceed 3 months. The complementary treatment for final alignment and settling continued with a multi-bracket appliance (MBT, 0.022-inch slot), when needed.

Ethical approval for the study was obtained from the Regional Committee for Medical and Health Research Ethics of North Norway (REK Nord 2010/2916). All participants and parents gave written informed consent. All treatment was performed by either the specialist orthodontist or orthodontic residents under the supervision of two specialists experienced in MALU treatment. The treatment plan with the MALU appliance was made independent of the present study.

Cephalometric Analyses

T1 and T2 cephalograms were traced digitally using the Facad software (Ilexis AB, Linköping, Sweden). The sagittal occlusion analysis[17] was used to assess changes in the dentoalveolar and skeletal complex (Figure 2). The occlusal line perpendicular (OLp) from the T1 cephalogram was used as a reference grid for all measurements in the sagittal plane. The grid was transferred from the T1 tracing to the T2 tracing by superimposition on the nasion-sella line with sella (S) as the registration point. Changes in the variables 3–6 represent the combined effect of skeletal and dental changes, and changes in the variables 7–10 represent skeletal changes. The variables 11–14 represent dental changes within the maxilla and mandible.

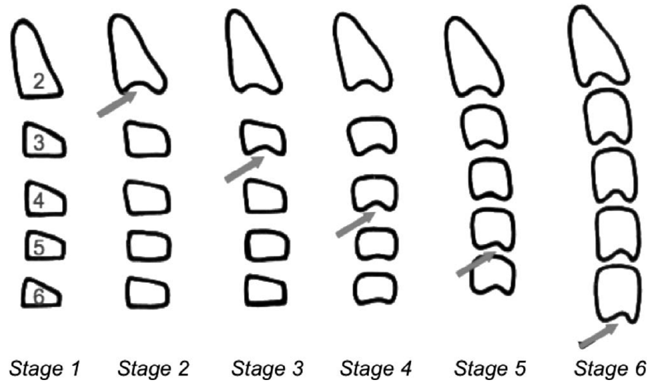

Figure 3. Cervical vertebral maturation (CVM) method.[32]

Changes in the Profile

The angle nasion-Point A-pogonion (N-A-Pg) was used to assess skeletal facial convexity. For soft tissue convexity, the corresponding soft tissue parameters (soft tissue nasion-soft tissue Point A-soft tissue pogonion) were used.

The cephalometric parameters used for analyzing the sagittal positions of the maxilla and mandible were SNA, SNB, SNPg, and ANB. For the vertical position, ML/NSL and ML/NL were used; incision line superius (Ils)/NSL and incision line inferius (Ili)/ML were used to describe the inclination of the incisors.

Assessment of Pubertal Growth Peak

The growth stage in relation to PGP was assessed on T1 cephalograms by the CVM method. The morphology of cervical vertebrae C2–C6 was visually inspected to determine skeletal maturity (Figure 3).[10] Based on this maturity, participants were divided into two groups according to their CS stage at T1: peak group = treatment initiation before or during PGP (CS1–CS3 at T1); postpeak group = treatment initiation after PGP (CS4–CS6 at T1).

Statistical Analysis

According to the power calculation, 20 patients (10 in each group) were needed to obtain a power of 80%, at significance level $P = .05$, based on previously detected mean changes of the mandibular jaw base position (OLp-Pg) from pre- to posttreatment.[17]

Data analysis was performed using the SPSS software (version 18.0; SPSS Inc, Chicago, Ill). For all variables, means with standard deviations were calculated. Normality of the data was verified visually on the histograms of different variables. Student's *t*-test was used to compare means of the different variables between groups at T1 and T2. Differences with P values <0.5 were considered statistically significant.

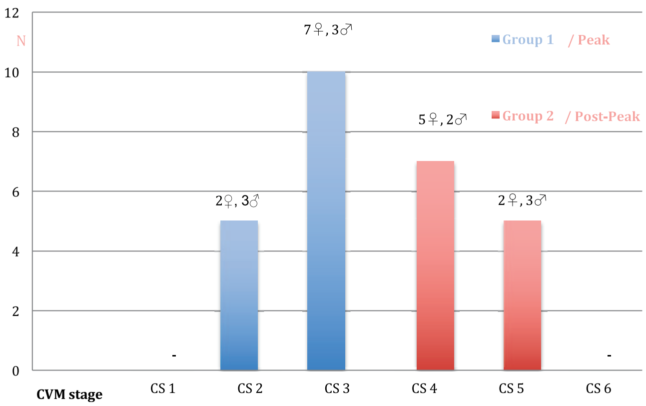

Figure 4. Distribution of the subjects in relation to different cervical vertebral maturation stages (CVM). CS 1–3 represents stages before and during the pubertal growth peak (PGP). CS 4–6 represents post-PGP stages.

Reliability of Measurements

Ten cephalograms at T1 were traced and measured twice by the same examiner at two different time periods after a memory-free period. The intraclass correlation coefficient (ICC) was used to evaluate the reliability of repeated measurements. ICC values for the examiner's first and second measurements ranged between 0.93 and 0.99 for linear and angular measurements, representing high to excellent reliability. For reliability of the CVM stage, the same examiner assessed all T1 cephalograms twice in a 2-week interval. In case of disagreement, the CVM was evaluated once more, which was used as the final value. The kappa value between the first and second CVM assessment was 0.647, representing substantial agreement. For 19/27 subjects, there was full agreement; for the remaining 8 subjects, the disagreement did not exceed one category.

RESULTS

According to the CVM analysis (Figure 4), 15 participants had treatment initiation before or during PGP and were placed in the peak group; 12 had passed PGP and were placed in the postpeak group. The mean ages of subjects in the peak and postpeak groups were 13.3 ± 0.7 years and 16.4 ± 1.4 years, respectively. The mean treatment time with the MALU appliance was 0.7 years (SD 0.09) for males and 0.7 years (SD 0.08) for females. Treatment time did not differ significantly between genders or between the peak and postpeak groups.

Except for maxillary and mandibular molar position, no significant differences in the investigated skeletal or dental parameters were found between groups at T1 (Tables 1 and 2). At T2, the mean ANB angle and proclination of mandibular incisors (Ili/ML) were significantly smaller in the peak group than in the postpeak group. The mean hard-tissue profile convexity was also significantly less in the peak group than in the postpeak group, 173.8° and 169.6°, respectively (Table 1). Mean overjet was 2.7 mm in the peak group and 1.8 mm in the postpeak group, and the difference was significant (Table 2).

Vertical jaw relationships showed practically no change from T1 to T2 in either group. In the peak group, the mandibular incisors tipped labially an average of 8.0°; in the postpeak group, the Ili/ML was

Table 1. Cephalometric Values for the Peak and Postpeak Groups Before and After Treatment With The Mandibular Advancement Locking Unit Appliance (MALU)

	T1 (Before Treatment)					T2 (After Treatment)				
	Peak Growth		Postpeak Growth			Peak Growth		Postpeak Growth		
Variable	Mean	SD[c]	Mean	SD	P^a	Mean	SD	Mean	SD	P^b
Sagittal jaw relationship										
SNA (°)	82.8	3.17	84.0	4.05	.387	82.1	3.12	83.5	3.92	.291
SNB (°)	77.1	2.84	77.4	4.16	.776	78.3	3.10	78.4	3.91	.925
SNPg (°)	78.6	3.09	78.0	4.22	.578	79.6	3.41	78.4	4.10	.419
ANB (°)	5.7	1.41	6.6	1.49	.071	3.8	1.68	5.1	1.31	.022*
Vertical jaw relationship										
ML/NSL (°)	28.0	4.46	28.8	5.25	.707	27.0	4.88	28.7	5.76	.437
ML/NL (°)	20.2	4.19	22.3	4.91	.245	19.6	4.92	21.6	5.35	.319
Incisor relationship										
Ils/NSL (°)	107.0	9.15	104.9	9.10	.572	104.4	4.89	102.1	5.68	.269
Ili/ML (°)	97.6	3.55	98.9	6.15	.528	105.6	3.67	110.6	5.04	.007**
Facial convexity										
Skeletal convexity (°)	171.0	4.49	167.6	5.87	.103	173.8	4.68	169.6	5.31	.042*
Soft tissue convexity (°)	155.7	5.27	153.5	7.39	.377	156.9	5.33	155.6	6.99	.576

P indicates *P* values for differences between peak and postpeak groups at T1 (P^a) and T2 (P^b).
[c] SD indicates standard deviation.
* $P < .05$; ** $P < .01$; *** $P < .001$.

Table 2. Dentoskeletal Cephalometric Values for Peak and Postpeak Groups Before and After Treatment With the Mandibular Advancement Locking Unit Appliance (MALU) According To The Sagittal Occlusion Analysis

	T1 (Before Treatment)					T2 (After Treatment)				
	Peak Group		Postpeak Group			Peak Group		Postpeak Group		
Variable	Mean	SD	Mean	SD	P^a	Mean	SD	Mean	SD	P^b
Combined dental and skeletal values										
Overjet (mm)	7.2	1.73	7.2	1.44	.998	2.7	1.23	1.8	0.80	.038*
Molar relationship[d] (mm)	2.0	1.81	1.5	1.94	.499	-2.8	1.16	-3.4	2.39	.453
Dental values										
Maxillary incisor (mm)	76.6	4.17	78.9	4.20	.169	76.6	4.91	78.5	4.13	.560
Mandibular incisor (mm)	69.4	4.11	71.7	4.53	.183	74.7	4.37	76.6	4.18	.255
Maxillary molar (mm)	47.8	3.66	50.8	3.95	.045*	47.4	3.98	49.3	4.54	.261
Mandibular molar (mm)	45.7	3.23	49.3	4.54	.019*	50.3	4.18	53.1	4.50	.099
Skeletal values										
Maxillary base (mm)	71.5	3.68	73.2	3.71	.265	72.5	3.79	73.2	3.59	.640
Mandibular base (mm)	68.6	3.58	69.4	4.72	.608	71.6	4.14	70.4	4.68	.477
Condyle (mm)	11.2	2.32	10.3	2.87	.386	12.1	2.27	10.5	3.01	.136
Mandibular length (mm)	79.7	3.54	79.7	4.57	.968	83.7	4.21	80.9	4.35	.103

P indicates *P* values for differences between peak and postpeak groups at T1 (P^a) and T2 (P^b).
[c] SD indicates standard deviation.
[d] Positive values indicate a distal molar relationship; negative values, a normal or mesial relationship.
* $P < .05$; ** $P < .01$; *** $P < .001$.

11.7°, but the change between groups was not significantly different (Table 3).

Changes According to the Sagittal Occlusion Analysis

Overjet was reduced by an average of 4.5 ± 2.2 mm in the peak group and 5.4 ± 1.3 mm in the postpeak group as a result of both skeletal and dental changes (Table 4, Figure 5). Lingual movement of the maxillary incisal point and labial movement of the mandibular incisal point were responsible for the improvement in incisor relationship (Table 2). The sagittal molar relationship was corrected both by skeletal and dental changes, mainly through mesial movement of the mandibular molars in both groups: 4.5 ± 2.10 mm in the peak group and 3.8 ± 0.97 mm in the postpeak group (Table 4). The mandibular base showed forward displacement in both groups. For total sagittal correction, the peak group included more skeletal contribution (54%) and less dental correction (46%) compared with the postpeak group (24% skeletal, 76% dental). Skeletal vs dental contribution in correction of overjet and molar relation are presented separately in Figure 5.

Table 3. Changes in Standard Cephalometric Values From T1 to T2 in the Peak and Postpeak Groups

	T1 (Before Treatment)–T2 (After Treatment)		T1–T2		
	PEAK Group		Postpeak Group		
Variable	Mean	SD[a]	Mean	SD	*P*
Sagittal jaw relationship					
SNA (°)	−0.7	1.08	−0.5	0.98	.555
SNB (°)	1.2	1.03	1.0	0.86	.482
SNPg (°)	1.0	1.06	0.4	0.94	.319
ANB (°)	−1.9	0.85	−1.5	0.86	.241
Vertical jaw relationship					
ML/NSL (°)	−1.0	1.50	−0.1	1.12	.085
ML/NL (°)	−0.6	1.90	−0.7	1.43	.917
Incisor relationship					
Ils/NSL (°)	−2.6	6.54	−2.8	5.46	.907
Ili/ML (°)	8.0	4.03	11.7	6.68	.113
Facial convexity					
Skeletal convexity (°)	2.8	2.06	2.0	1.29	.259
Soft tissue convexity (°)	1.2	2.69	2.1	1.75	.333

[a] $P = P$ values for differences between peak and postpeak groups.
* $P < .05$; ** $P < .01$; *** $P < .001$.

DISCUSSION

Reliability of cephalometric landmarks and measurements is of major importance, especially when the results are based solely on cephalometric analyses, as they were in our study.[18,19] Our repeated intraexaminer measurements showed high to excellent agreement for all angular and linear variables included in the study, indicating that measurement error was not an issue. The reason for using the sagittal occlusal (SO) analysis by Pancherz[2] in evaluating sagittal dentoskeletal changes was to compare our results with former studies; nevertheless, the occlusal plane is not considered a stable reference frame due its capability for inaccuracy during superimposition of cephalograms.[20] This eventual method error must be kept in mind when interpreting the resulting dentoskeletal changes, which are based solely on the SO analysis. Another source of error could be that a different

Table 4. Changes in Dentoskeletal Cephalometric Values From T1 to T2 In the Peak and Postpeak Groups According to the Sagittal Occlusion Analysis

	T1 (Before Treatment)– T2 (After Treatment)		T1–T2		
	Peak Group		Postpeak Group		
Variable	Mean	SD[a]	Mean	SD	*P*
Combined dental and skeletal values					
Overjet (mm)	−4.5	2.20	−5.4	1.30	.206
Molar relationship (mm)	−4.8	1.98	−4.9	1.97	.962
Dental values					
Maxillary incisor (mm)	0.9	2.30	−0.4	1.90	.138
Mandibular incisor (mm)	5.4	1.90	5.0	2.00	.654
Maxillary molar (mm)	−0.3	1.81	−1.5	1.84	.103
Mandibular molar (mm)	4.5	2.10	3.8	0.97	.028*
Skeletal values					
Maxillary base (mm)	1.0	0.99	0.1	0.67	.007**
Mandibular base (mm)	3.0	2.04	1.0	0.52	.002**
Condyle (mm)	0.9	0.78	0.2	0.63	.018*
Mandibular length (mm)	4.0	2.10	1.2	0.89	.001**

$P = P$ values for differences between peak and postpeak groups.
* $P < .05$; ** $P < .01$; *** $P < .001$.

orthodontist performed the treatments in the study, which could reflect in treatment time. However, the effect of individual performers seemed small, as they worked under the same supervision, they all followed the guidelines concerning MALU treatment, and the variation in treatment time was no more than a few months.

Except for the first (CS1) and last (CS6) stages of growth, participants were rather evenly distributed across the stages, indicating that all subjects were growing, whether before, during, or after the PGP. Since our aim was to analyze the mode of Class II correction with regard to PGP, only patients who had completed MALU reatment with a Class I sagittal relationship obtained in both first molars and canines were included in the study. Of the three excluded patients whose treatments were interrupted, one showed unfavorable posterior rotation of the mandible and two had repeated breakdowns of the appliance.

Skeletal changes contributed more to Class II correction among the subjects who started MALU treatment before or during PGP than among those who were past PGP, which was also reflected in the mandibular ANB values in the peak group. This is in line with earlier results on the Herbst appliance, which showed the biggest growth changes in subjects treated during PGP.[5,7,21] Participants who were close to the end of their growth period at treatment initiation showed small, clinically irrelevant skeletal changes, which was reflected in the increased dental compensation in overjet correction compared with that of the younger participants. Ruf and Pancherz have reported slight but significant mandibular growth changes in patients treated with the Herbst appliance who had passed the PGP.[5,22] Others have suggested that treatment with the Herbst appliance forces the mandible anteriorly by utilizing normal mandibular growth capacity.[5,8,23,24] In spite of the minor skeletal component in Class II correction that we observed in patients who were treated after their PGP, our results with the MALU appliance support the general view that optimal treatment timing for skeletal Class II patients is during the circumpubertal growth period, when the likelihood of maximum growth response is highest.[7,10,23]

General parameters for growth evaluation, such as body height and characteristics of sexual maturity, were not available. We determined stage of growth retrospectively on pretreatment lateral cephalograms using the CVM method. Despite its limitations, such as low sensitivity of stages away from the circumpubertal

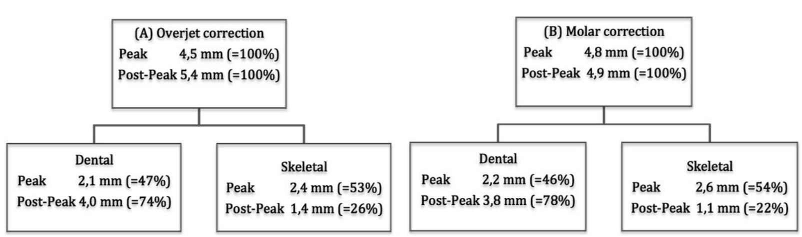

Figure 5. Calculated contribution of skeletal and dental changes in the mechanism of overjet correction (A) and of molar correction (B).

period, the CVM method has shown high correlation between the hand-wrist method and the CVM method.[25] Differentiation of the morphological characteristics of the vertebral bodies between CVM stages has been shown to be difficult due to possible positional changes of the vertebral column during cephalometric x-ray exposure.[26] In our study, intraexaminer reliability of the CVM stage was tested to show that the kappa value represented substantial agreement. In a cephalometric implant study, Gu and McNamara[23] found that the average duration of the CS2 stage was 15 months, about 17 months for CS3, and 18 months for CS4. Even if each stage lasted roughly 1 years, it is not possible to define at which exact point a person is within a given stage at the time of the cephalogram.[23] The evidence shows that up to the end of CS3, adolescents are generally in the acceleration phase of PGP; thus, we used this as the basis to define the groups in our study.[10,23,27] After CS3, participants were supposed to be beyond PGP, that is, in the late stage of their growth period. However, if several of the participants in our peak group were in their late CS3 stage at the time of the cephalogram and moved to CS4 soon after treatment initiation, it could have affected the results by reducing the difference in skeletal change between the groups.

Vertical jaw relations did not change in our patients treated with the MALU appliance. This is in line with recent results for both growing and nongrowing patients treated with the Herbst appliance, but in contrast to an early study by Pancherz, who reported clockwise rotation of the mandible, which he suggested was a result of mandibular molar extrusion.[2,3,5]

Part of the overjet correction was due to tipping of the mandibular incisors, which showed large individual variation, but which was significantly more pronounced in the postpeak group. Proclination of the mandibular incisors was not surprising, since similar results have been reported previously in adolescents using the Herbst appliance.[28] It seems that the anchorage was not enough to resist the pressure exerted on the mandibular incisors via the MALU force system. However, after MALU treatment, the mandibular incisors were more proclined in the late treatment group, suggesting that more incisal compensation was needed for Class II correction when treatment was started after PGP. Weschler and Pancherz addressed labial tipping as anchorage loss.[29] Several different anchorage designs for the Herbst appliance have been investigated, and none of them seemed to withstand the forces directed to the mandibular dentition, leading to the conclusion that labial tipping of these teeth is still an unsolved problem during Herbst treatment.[29,30] In this study, we followed the MALU protocol, wherein the mandibular advancement forces were directed to the mandibular incisors through the archwire-bracket system. However, our treatment results with MALU suggest that some kind of anchorage reinforcement, for example, a lingual arch or combining teeth into larger entities in the maxilla and mandible with negative root torque would be required for better tipping control of the mandibular incisors. We can only speculate whether an initial stepwise activation of the MALU appliance could have resulted in a more skeletal contribution in both groups, as has been shown for the Herbst appliance in a study by Du and coworkers.[31]

According to the aims, our study was limited only to the MALU phase. Neither total treatment time nor stability of treatment were analyzed in this context. The small sample size and lack of an untreated control group were clear limitations of this study. Postponing treatment of suitable patients to serve as controls was not considered ethically acceptable, as the patients were already in their teens. Data from existing growth studies could not be utilized here, since the reported normal values are presented by chronological age, not skeletal maturation, which was the main focus of our study. The presented net changes during MALU treatment in our study are a combined result of natural growth and treatment. The impact of natural growth on the net change cannot be separated from the actual treatment effect in this study set-up, which must be kept in mind while making inferences from the net changes. Therefore, we think that the main interest of our study is the question of whether the cephalometric parameters contributing to Class II correction during treatment with the MALU appliance differ between patients who started treatment before or during PGP and those starting after the PGP. The treatment effect of the MALU appliance per se was beyond the scope of this study.

CONCLUSIONS

- Our results suggest that, in the treatment of skeletal Class II patients with the MALU appliance, the mode of correction depends on stage of growth. The null hypothesis was rejected.
- If treatment is started before or during PGP, the result seems to be a more favorable SNA/SNB relationship and less tipping of the mandibular incisors than if started after the PGP.

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