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Featured Original Research

"Spontaneous" correction capacity of skeletal Class II malocclusions in growing patients after upper and lower arch coordination using fixed appliances: A prospective controlled clinical study

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ABSTRACT

Objective: To determine the effect of arch coordination on the dentoskeletal jaw base relationship and the mandibular growth pattern in growing skeletal Class II patients.
Materials and Methods: Leveling, aligning, and upper/lower arch coordination were done in 30 Class II/1 growing patients with preadjusted edgewise fixed appliances. After arch coordination was achieved without transverse discrepancy and occlusal interferences, the 6-month experimental passive observation period was started. The records were compared with 30 untreated patients who served as controls. The initial (T_0) and post-coordination+observation (T_1) cephalograms of two groups were analyzed and compared using standard cephalometric parameters, Pancherz analysis, and cranial base superimposition.
Results: Sagittal maxillary growth in the treated group was slightly restricted, in turn resulting in a decrease in profile convexity. Mandibular sagittal growth did not differ between groups, but the mandible rotated posteriorly in the treated and anteriorly in the control group. The upper incisors were retroclined and retruded in the treated group, resulting in overjet reduction. The lower incisors were intruded in the treated group, leading to overbite reduction. The cephalometric superimposition over the stable structures of the anterior cranial base showed higher prevalence for the forward rotation with forward pogonion position and increased vertical dimension in the control group.
Conclusions: Upper and lower arch coordination alone does not seem to affect mandibular growth; however, because of a posterior rotation of the mandible, it does affect the direction of mandibular growth in some patients, although not in the desired therapeutic direction. (ClinicalTrials.in.th: TCTR20170706003).

1. Introduction

Typical Class II malocclusion characteristics include protrusive upper incisors, retrusive chin, and convex facial profile [1], which often present with mandibular retrusion [2]. It is generally accepted that self-correction of Class II malocclusion to a clinically significant degree cannot be expected and it persists from childhood to adulthood [3].

Several appliances are available for comprehensive Class II treatment, and their treatment efficacy has been widely analyzed. In contrast, the effect of interceptive orthodontic measures on Class II correction remains poorly understood. It has been proposed that a mechanical unlocking of occlusion by means of occlusal interference removal could promote a physiologic development of jaws [4]; however, the effect of such an approach remains controversial.

It is well established that Class II division 1 patients have smaller maxillary skeletal base and dental arch widths [5]. Comprehensive Class II treatment usually includes transverse maxillary expansion [6,7]. It has been reported that already a transverse maxillary expansion alone, by unlocking the occlusion, may lead to a spontaneous improvement of Class II malocclusions [7–13]. Being able

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to predict the size and amount of such a spontaneous improvement would be very useful for orthodontic treatment planning [14]. However, the amount and consistency of this effect are controversial [9,14,15], and a corresponding systematic review [16] came to the conclusion that the effect of rapid maxillary expansion (RME) on sagittal Class II correction has not been proven yet.

It has been hypothesized that patients occlude more easily in the anterior position after transverse expansion, which in turn promotes forward mandibular posturing and growth [17]. RME might correct only the transverse problem, whereas deep bite and other occlusal interferences, which may act as mechanical locking factors for the mandible [5], could prevail. The latter could be achieved by aligning, leveling, and coordinating the dental arches with multibracket appliances to obtain optimal conditions for a spontaneous Class II correction.

Therefore, the purpose of this study was to assess the effect of arch coordination on the dentoskeletal jaw base relationship and the mandibular growth pattern in growing skeletal Class II patients. The null hypothesis was that there would be no difference in the amount and/or direction of mandibular growth between the treated and control samples.

2. Materials and methods

This study was approved by the ethics committee on human research at the Faculty of Dentistry, Prince of Songkla University, and registered in the Thai Clinical Trials Registry (TCTR20170706003). All participants and their parents provided informed consent before participating in this study.

2.1. Subjects

Sample size was calculated with PS software (Nashville, TN) based on the parameter (pg/OLp$_{mm}$; distance from pogonion to occlusal line perpendicular) taken from study of Class II/1 treatment with fixed appliance in growing patients [18] with mean treatment change of 2.1 mm and standard deviation of 2.8. The significance level and power were established at 95% ($\alpha = 0.05$) and 80% ($\beta = 0.2$), respectively. A minimum of 29 individuals in each group was required.

The inclusion criteria for the treatment (Tx) and control groups were as follows: 1) mild to moderate skeletal Class II patients (angle formed by the intersection of lines from points A and B to point N [ANB] = 4–9°); 2) Class II division 1 malocclusion where canine, premolar, and molar teeth exhibit Class II relationship (Class I intercuspation was not seen); 3) increased overjet 5 to 12 mm; 4) deep curve of Spee; 5) growing patients with hand-wrist-radiographic stages 4–5 according to Björk (1972) [19] and Grave and Brown (1976) [20]; 6) convex facial profile (FCA; angle form by intersection of glabella-subnasale line and subnasale-soft tissue pogonion line >13°); 7) no previous orthodontic treatment; 8) no systemic or degenerative temporomandibular joint disease; and 9) late mixed or permanent dentition without agenesis or dental/craniofacial anomalies.

The subjects for the treated group (mean age 11.40 ± 0.96) were recruited prospectively by assigning the first 30 patients who met the inclusion criteria and enrolling treatment at the dental hospital from May to December 2015 (15 girls/15 boys). The control group (mean age 11.03 ± 1.03) comprised 30 untreated subjects (16 girls/14 boys). The control group was recruited both pro- and retrospectively from three data sources of our hospital: 1) prospective records of growth monitoring patients on the waiting list (all underwent comprehensive orthodontic care after trial completion); 2) retrospective records of previous growth monitoring patients who were currently receiving or had completed orthodontic treatment; and 3) treatment records of growing patients who refused orthodontic treatment.

2.2. Treatment protocol

The treatment was provided by an orthodontist (C.C.) at dental hospital, Prince of Songkla University. Leveling and aligning was performed in the treated sample using preadjusted edgewise appliances with 0.018 × 0.025-inch slot on incisors and 0.022 × 0.028-inch slot on the canines and posterior teeth (Roth system; Ormco, Orange, CA). A standardized archwire protocol was used to achieve a coordination of upper and lower dental arches: 1) 0.012-inch nickel-titanium (NiTi) to 0.016 × 0.016-inch NiTi; 2) 0.016 × 0.022-inch titanium molybdenum alloy (TMA); 3) 0.016 × 0.022-inch TMA with intrusive step for lower incisors; and 4) 0.016 × 0.022-inch stainless steel. No further appliances, intermaxillary mechanics, or auxillaries were used during the active treatment phase or the subsequent passive trial period.

The achievement of upper to lower arch coordination was tested clinically by having the patients bite in a protrusive/Class I position (Fig. 1). If a Class I with normal overjet and overbite occlusion could be obtained without transverse or other occlusal interferences, the experimental passive observation period was started and no further appliance adjustments were performed. Mean duration for achieving arch coordination was 12 months followed by passive observation period of 6 months, then records were taken.

After the end of trial, the treated group was individually reassessed to determine remaining orthodontic treatment need. The required treatment was provided to all patients. As the corresponding changes are not part of the present trial itself, the results are not reported in this article.

2.3. Method

Cephalograms from initial (T0) and post-coordination+observation (experimental) or exclusively observation (control) (T1) were evaluated. All digital radiographs were taken with the same machine: Gendex GXDP-700 (Hatfield, PA), with 10% magnification rate. No correction for linear enlargement was performed. The tracing, landmark registration, and measurements were performed by the primary investigator (K.K.) using Dolphin Imaging software (version 11.7.05.66; Chatsworth, CA). All cephalograms appeared pseudonymized in the software; therefore, the investigator was blinded with respect to T0 group assignment but for natural reasons could see multibracket appliances and thus T1 group assignment.

The distances and angles used for cephalometric evaluation are illustrated in Figure 2. For Pancherz analysis, T_0 and T_1 tracing were superimposed on the Nasion-Sella line at Sella point, then, OL/OLp (Occlusal line and occlusal line perpendicular) reference grid from T_0 was transferred to T_1 on the Dolphin software. In addition, the radiographs were superimposed using stable anatomic structures of anterior cranial base according to Björk and Skieller (1972) [21] to assess the mandibular positional changes. For a better comparison for the changes in molar relationship, this measurement was done without transferring the OL/OLp reference grid, thus relative to their own respective (T_0 or T_1) occlusal lines.

2.4. Statistical method

Statistical analyses were performed using SPSS 17.0 software (IBM Corp., Chicago, IL). Statistical significance was set at $P < 0.05$. Normal data distribution was tested with the Shapiro-Wilk test. Gender differences within each group were examined using independent *t*-tests, which were found to be insignificant, so genders were pooled. Independent *t*-tests were used to compare the T_0 characteristics and changes from T_0 to T_1 between the treated and control groups. For non-normally distributed variables, the Mann-

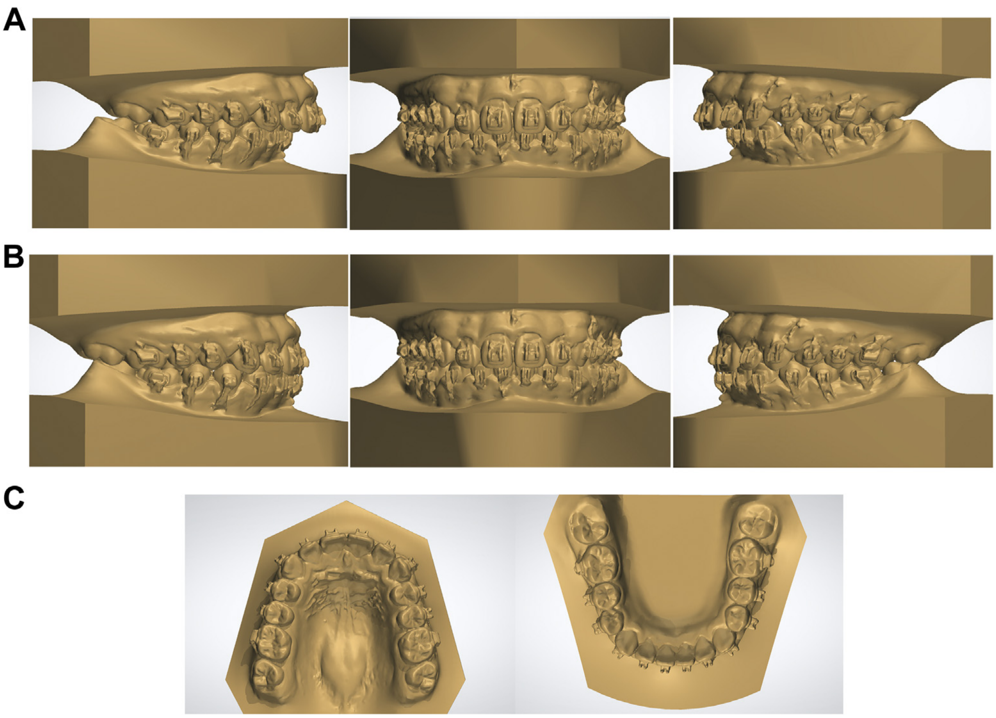

Fig. 1. Typical occlusal situation after arch coordination: (A) in maximum intercuspation, (B) in simulated (protruded) Class I position, (C) typical alignment situation.

Whitney *U* test was used instead. Differences in growth pattern (T_0 to T_1) between the treated and control groups were analyzed with the χ^2 test.

2.5. Method error

The size of the combined method error was calculated by the Dahlberg formula [22]. The analysis was repeated on 15 randomly selected radiographs from each time point at intervals of 2 months.

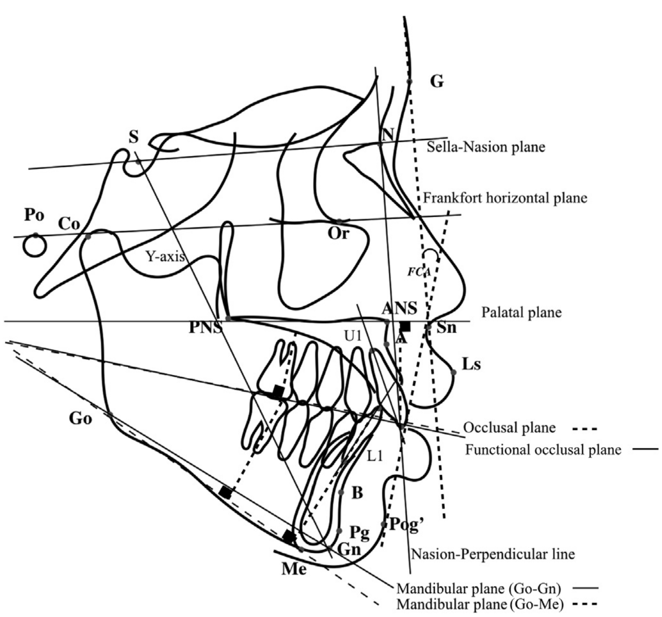

Fig. 2. Cephalometric landmarks used and vertical position of incisor and molar assessments (measured from incisal edge, respectively, mesio-buccal molar cusp tip to corresponding references).

The method error for linear and angular measurements did not exceed 0.5 units for any variables investigated.

3. Results

The demographic data of both groups are shown in Table 1. Both initial age and length of observation period showed no significant differences between groups. There were 15 boys (50%)/15 girls (50%) in the treated group and 14 boys (47%)/16 girls (53%) in the treated group. The χ^2 test showed sex distribution was compatible among the groups (114.375χ^2; $P = 0.000$).

All cephalometric values for both groups at T_0 and T_1 timepoints and the changes between T_0 and T_1 are illustrated in Tables 2–4. All initial parameters except for the FCA° were comparable without significant differences. The treated group (Tx) showed more pronounced profile convexity (+3°, $P = 0.012$) than the controls.

The sagittal skeletal changes showed significant maxillary differences. Sella nasion point A (SNA)° decreased in the Tx but increased in the controls (−0.7° vs. +0.1°, $P = 0.027$). In contrast, the sagittal skeletal mandibular parameters showed insignificant differences between groups. The profile convexity was significantly reduced in the Tx group by 2.3° but increased in the controls by 1.3° ($P = 0.000$).

The vertical skeletal parameters revealed significant differences for changes in SN/MP° (Angle between sella-nasion plane and mandibular plane), which increased in the Tx group and decreased in the controls (+0.5° vs. −0.8°, $P = 0.012$).

Table 1
Demographic data for treated and control groups

Groups	Age at T_0, y	$T_0 - T_1$ interval, y
	Mean ± SD	Mean ± SD
Treated group	11.40 ± 0.96	1.63 ± 0.51
Control group	11.03 ± 1.03	1.42 ± 0.57
Significance	NS	NS

NS indicates not significant, $P \geq 0.05$.

Table 2
Cephalometric values of initial (T_0), post-arch coordination (T_1), and changes ($T_1 - T_0$) with the *P* value between treated and control groups

Measurement	Group	T0	T1	T1 − T0	Treatment - control
		Mean ± SD	Mean ± SD	Mean ± SD	Significant changes
Sagittal jaw relationship					
SNA°	Treated	83.85 ± 3.10	83.18 ± 3.52	−0.67 ± 1.52	*
	Control	83.97 ± 3.38	84.11 ± 3.18	0.14 ± 1.22	
	P	0.887	0.287	0.027	
SNB°	Treated	77.46 ± 3.81	77.68 ± 3.88	0.22 ± 1.33	NS
	Control	78.00 ± 3.29	78.58 ± 3.63	0.58 ± 1.62	
	P	0.556	0.359	0.361	
ANB°	Treated	6.40 ± 1.99	5.50 ± 2.11	−0.90 ± 1.11	NS
	Control	5.97 ± 2.11	5.29 ± 2.61	−0.68 ± 2.00	
	P	0.416	0.729	0.601	
Co-Amm	Treated	86.10 ± 5.24	88.74 ± 4.53	2.63 ± 2.54	NS
	Control	85.80 ± 6.65	88.54 ± 5.53	2.74 ± 3.61	
	P	0.843	0.879	0.895	
Co-Gnmm	Treated	108.91 ± 6.56	114.66 ± 6.84	5.76 ± 3.31	NS
	Control	107.59 ± 7.21	112.55 ± 6.13	4.97 ± 4.93	
	P	0.461	0.213	0.470	
A-Nperpmm	Treated	2.08 ± 2.48	2.18 ± 3.13	0.10 ± 2.03	NS
	Control	1.20 ± 3.43	1.61 ± 3.12	0.41 ± 1.57	
	P	0.262	0.488	0.507	
Pg-Nperpmm	Treated	−7.86 ± 5.33	−5.84 ± 6.12	2.02 ± 3.87	NS
	Control	−8.50 ± 5.48	−7.38 ± 5.47	1.13 ± 4.03	
	P	0.646	0.308	0.383	
Vertical jaw relationship					
SN/MP°	Treated	36.36 ± 5.89	36.85 ± 6.13	0.48 ± 1.87	*
	Control	36.82 ± 5.21	36.05 ± 5.65	−0.77 ± 1.86	
	P	0.750	0.604	0.012	
FH/MP°	Treated	28.18 ± 5.14	27.93 ± 5.33	−0.25 ± 1.83	NS
	Control	29.63 ± 4.93	29.09 ± 4.70	−0.54 ± 3.24	
	P	0.268	0.374	0.671	
NS/Gn°	Treated	69.12 ± 4.49	69.58 ± 4.51	0.46 ± 1.44	NS
	Control	68.85 ± 3.62	68.74 ± 4.06	−0.10 ± 1.88	
	P	0.794	0.451	0.198	
Occlusal plane relationship					
SN/OP°	Treated	20.18 ± 5.30	16.61 ± 6.99	−3.57 ± 5.18	NS
	Control	19.31 ± 6.05	18.12 ± 5.20	−1.20 ± 5.30	
	P	0.557	0.348	0.085	
FH/OP°	Treated	11.98 ± 4.26	8.02 ± 5.15	−3.96 ± 4.88	NS
	Control	12.29 ± 5.55	10.71 ± 4.60	−1.58 ± 5.83	
	P	0.807	0.037	0.092	
Dental relationship					
U1/NA°	Treated	30.67 ± 9.16	24.80 ± 6.05	−5.87 ± 8.93	****
	Control	31.46 ± 7.18	32.11 ± 8.62	0.65 ± 3.09	
	P	0.714	0.000	0.000	
U1-NAmm	Treated	7.84 ± 3.05	6.40 ± 2.36	−1.44 ± 3.03	**
	Control	8.01 ± 3.07	8.61 ± 3.40	0.59 ± 2.61	
	P	0.827	0.005	0.007	
L1/NB°	Treated	31.77 ± 7.21	33.09 ± 6.52	1.32 ± 7.99	NS
	Control	30.56 ± 7.65	31.43 ± 7.27	0.87 ± 7.71	
	P	0.529	0.355	0.826	
L1-NBmm	Treated	8.26 ± 2.81	8.10 ± 2.82	−0.16 ± 2.51	NS
	Control	7.93 ± 2.58	8.20 ± 2.87	0.27 ± 1.44	
	P	0.634	0.889	0.413	
U1/L1°	Treated	111.16 ± 9.69	116.59 ± 9.99	5.42 ± 12.58	*
	Control	111.01 ± 8.00	110.93 ± 9.73	−0.07 ± 3.62	
	P	0.946	0.030	0.025	
U1/PP°	Treated	123.03 ± 9.52	116.72 ± 6.71	−6.31 ± 9.02	****
	Control	123.64 ± 5.19	124.49 ± 6.59	0.85 ± 3.36	
	P	0.759	0.000	0.000	
L1/MP°	Treated	97.93 ± 7.39	98.58 ± 5.92	0.64 ± 8.14	NS
	Control	96.74 ± 6.72	96.36 ± 7.01	−0.38 ± 3.61	
	P	0.516	0.192	0.533	
Overjetmm	Treated	8.86 ± 3.07	6.51 ± 1.81	−2.35 ± 2.65	****
	Control	8.69 ± 3.16	8.97 ± 3.36	0.27 ± 1.69	
	P	0.836	0.734	0.000	
Overbitemm	Treated	3.93 ± 2.47	2.07 ± 1.76	−1.86 ± 2.03	****
	Control	3.36 ± 1.92	3.55 ± 2.12	0.19 ± 1.10	
	P	0.325	0.241	0.000	
ADHmm	Treated	28.52 ± 3.44	29.43 ± 3.34	0.91 ± 1.31	NS
	Control	28.55 ± 2.38	29.17 ± 2.50	0.62 ± 1.84	
	P	0.972	0.734	0.490	

(*Continued on next page*)

Table 2 (*Continued*)

Measurement	Group	T0	T1	T1 − T0	Treatment - control
		Mean ± SD	Mean ± SD	Mean ± SD	Significant changes
PDHmm	Treated	17.12 ± 2.39	18.51 ± 2.12	1.39 ± 1.81	NS
	Control	16.80 ± 2.21	17.54 ± 1.70	0.74 ± 1.31	
	P	0.585	0.246	0.119	
Nasolabial angle					
NLA°	Treated	99.14 ± 11.14	98.67 ± 8.93	−0.47 ± 10.27	NS
	Control	98.42 ± 11.23	100.41 ± 12.10	1.98 ± 10.55	
	P	0.805	0.529	0.365	
Profile convexity					
FCA°	Treated	20.90 ± 5.89	18.59 ± 6.14	−2.31 ± 3.85	****
	Control	17.14 ± 5.32	18.43 ± 5.89	1.29 ± 3.29	
	P	0.012	0.920	0.000	

ANB, A point, nasion, B point; FH, Frankfort horizontal plane; Gn, gnation; L1, lower central incisor; Me, menton; MP, mandibular plane; SNA, sella nasion point A; SNB, sella nasion point B; U1, upper central incisor.
**P* = 0.05; ***P* = 0.01; ****P* = 0.001; *****P* = 0.0001; NS indicates not significant, *P* ≥ 0.05.

Table 3
The number of vertical incisor and molar changes related to their skeletal bases from T_0 to T_1

Measurement	Group	T1-T0	Treatment -control	
		Mean ± SD	*P* Value	Significant changes
U1 vert change$_{mm}$	Treated	0.91 ± 1.31	0.490	NS
	Control	0.62 ± 1.84		
U6 vert change$_{mm}$	Treated	1.39 ± 1.81	0.119	NS
	Control	0.74 ± 1.31		
L1 vert change$_{mm}$	Treated	−0.23 ± 0.90	0.000	*
	Control	1.53 ± 1.21		
L6 vert change$_{mm}$	Treated	1.53 ± 1.56	1.000	NS
	Control	1.53 ± 1.20		

vert, vertical; U, upper; L, lower.
* *P* = 0.0001; NS indicates not significant, *P* ≥ 0.05.

Table 4
Cephalometric values related to occlusal line perpendicular of initial (T_0), post-arch coordination (T_1), and changes ($T_1 - T_0$) for treated and control group

Measurement	Group	T_0 Mean ± SD	T_1 Mean ± SD	$T_1 - T_0$ Mean ± SD	Treatment-control Significant changes
ss-OLp$_{mm}$	Treated	78.43 ± 3.93	79.39 ± 4.04	0.96 ± 1.91	*
	Control	77.41 ± 5.92	80.15 ± 5.51	2.74 ± 3.05	
	P	0.433	0.621	0.009	
pg-OLp$_{mm}$	Treated	80.35 ± 4.86	83.08 ± 5.75	2.73 ± 2.69	NS
	Control	80.83 ± 7.06	84.18 ± 7.71	3.35 ± 5.12	
	P	0.763	0.414	0.557	
co-OLp$_{mm}$	Treated	6.93 ± 2.69	8.29 ± 2.58	1.36 ± 1.86	NS
	Control	7.64 ± 3.51	8.09 ± 3.40	0.45 ± 1.95	
	P	0.383	0.623	0.070	
gn-OLp+ co-OLp$_{mm}$	Treated	87.29 ± 5.17	91.38 ± 5.53	4.08 ± 3.22	NS
	Control	88.15 ± 6.81	92.27 ± 6.32	4.12 ± 5.11	
	P	0.585	0.526	0.976	
is-OLp $_{mm}$	Treated	92.20 ± 4.59	91.70 ± 5.05	−0.50 ± 3.62	***
	Control	91.80 ± 5.98	95.05 ± 5.91	3.25 ± 4.47	
	P	0.771	0.268	0.001	
ii-OLp $_{mm}$	Treated	82.96 ± 5.47	85.06 ± 5.35	2.10 ± 2.80	NS
	Control	82.80 ± 6.67	85.89 ± 6.59	3.10 ± 3.44	
	P	0.918	0.529	0.225	
ms-OLp $_{mm}$	Treated	56.91 ± 3.76	59.84 ± 4.32	2.93 ± 2.17	NS
	Control	55.77 ± 4.88	59.22 ± 5.37	3.45 ± 3.22	
	P	0.315	0.046	0.469	
mi-OLp $_{mm}$	Treated	55.99 ± 4.50	59.83 ± 4.99	3.84 ± 2.39	NS
	Control	55.44 ± 5.27	59.14 ± 6.24	3.70 ± 3.22	
	P	.663	.121	.845	
ms-OLp$_{mm}$−mi-OLp$_{mm}$	Treated	0.90 ± 2.43	0.01 ± 2.56	−0.89 ± 1.59	NS
	Control	0.33 ± 2.29	0.17 ± 2.51	−0.16 ± 1.55	
	P	0.353	0.509	0.075	
is-OLp$_{mm}$− ii-OLp$_{mm}$	Treated	9.16 ± 3.87	7.19 ± 1.92	−1.97 ± 3.24	****
	Control	7.41 ± 3.20	8.98 ± 3.58	1.56 ± 2.62	
	P	0.062	0.080	0.000	

**P* = 0.05; ***P* = 0.01; ****P* = 0.001; *****P* = 0.0001; NS indicates not significant, *P* ≥ 0.05.

The sagittal dental relationship showed significant change for upper incisors. The inclination in the Tx group was reduced by 6° for both U1/NA° and U1/PP° (distance between incisal tip of maxillary incisors and the line from nasion to point A), whereas their proclination increased in the controls ($<1°$) ($P = 0.000$). The position from U1-NA$_{mm}$ displayed a retrusion by 1.4 mm in the Tx group, whereas the controls showed 0.6-mm protrusion ($P = 0.007$). The overjet was reduced by 2.4 mm in the Tx group, whereas an increase of 0.3 mm was found in the control group ($P = 0.000$).

The vertical dental changes relative to their corresponding skeletal bases showed insignificant change of the upper anterior/posterior and lower posterior teeth position (Table 3). An extrusion of lower anterior teeth by 1.5 mm was seen for the controls, whereas intrusion of 0.2 mm was found for the Tx group, so treatment resulted in a relative intrusion of 1.7 mm ($P = 0.000$). A significant overbite reduction of approximately 2 mm was found in the treated group opposite to the increase by 0.2 mm in the controls ($P = 0.000$).

The results of the Pancherz analysis (Table 4) demonstrated a significant maxillary incisor retrusion by 0.5 mm in the Tx group, whereas the amount of protrusion increased (+3.3 mm) in the controls ($P = 0.001$). The overjet decreased significantly (−2.0 mm) in the Tx group compared with an increase by 1.6 mm in the control group ($P = 0.000$).

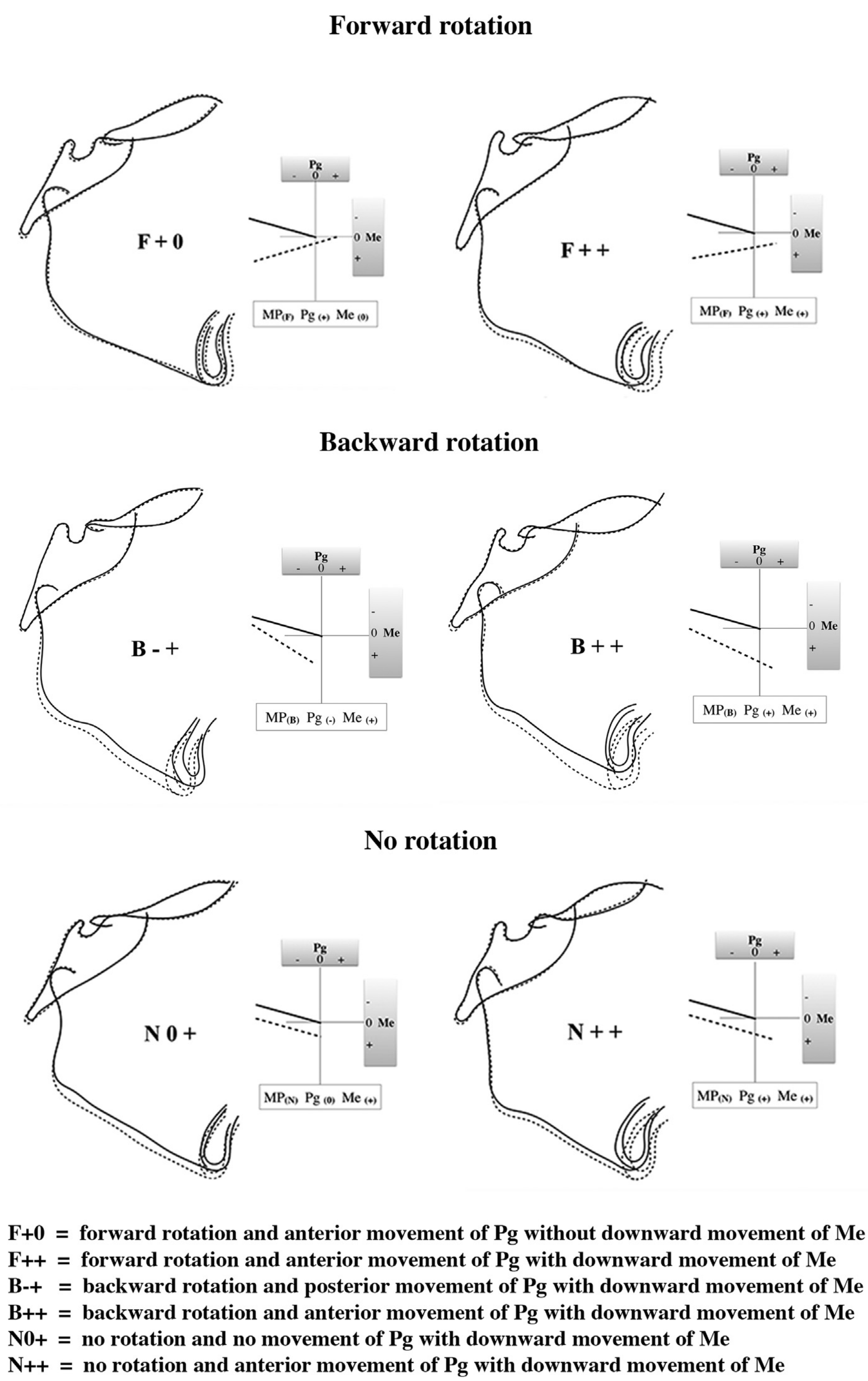

Fig. 3. Mandibular position changes relative to cranial base from before treatment (bold lines) to after coordination plus 6-month observation (broken lines) seen in both groups.

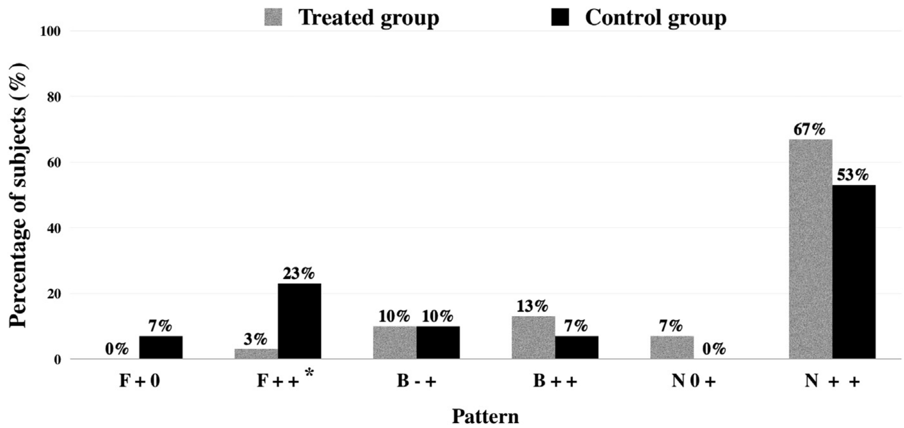

Fig. 4. Frequency (%) of six mandibular position change patterns.

The cephalometric superimposition over the stable structures of anterior cranial base showed that the mandibular positional change could be divided into six patterns according to the rotation of the mandibular plane, the sagittal changes of pogonion, and the vertical change of Menton (Fig. 3). The percentage distribution of each of the six patterns is given in Figure 4 and Table 5. The N++ (no rotation with forward pogonion position and increase vertical dimension) was the most frequent growth pattern in both groups. The overall χ^2 test did not show significant differences for the prevalence of different patterns between groups ($P = 0.087$); however, the likelihood ratio differed significantly ($P = 0.039$). Therefore, each pattern was tested separately using the *z*-test, revealing a higher prevalence for the F++ pattern (forward rotation with forward pogonion position and increase vertical dimension) in the control group ($P = 0.021$).

The categorized changes in sagittal skeletal jaw base relationship according to the ANB-angle are given in Figure 5 and Table 5. An improvement in ANB-angle was seen in 53% of the Tx but only 27% of the control group. A deterioration in jaw base relationship occurred to similar extents in both groups (7% Tx and 10% controls).

The categorized changes in molar relationship measured without transfer of OL/OLp are given in Figure 6 and Table 5. The average improvements in molar relationship were less than 1 mm in both groups and statistically insignificant. The prevalence of subjects showing improvement was higher in the Tx group than the controls (40% vs. 23%); however, the percentage of subjects exhibiting a deterioration in molar relationship was higher in the Tx group (13% vs. 7%).

4. Discussion

Several possible mechanisms for a spontaneous sagittal Class II improvement after treatment of maxillary transverse problems have been discussed: utilization of Leeway space [23], distal-in-molar-rotation induced by expanders [9], increased functional contact [24], elimination of functional shifts and occlusal

Table 5
Percentage (%) shown in the change of patterns, jaw base relationship according to ANB-angle, and molar relationship

Patterns		Treated group, %		Control group, %
F + 0 [$MP_{(F)}$ $Pg_{(+)}$ $Me_{(0)}$]		0.0		7.0
F + + [$MP_{(F)}$ $Pg_{(+)}$ $Me_{(+)}$]		3.0		23.0
B − + [$MP_{(B)}$ $Pg_{(-)}$ $Me_{(+)}$]		10.0		10.0
B + + [$MP_{(B)}$ $Pg_{(+)}$ $Me_{(+)}$]		13.0		7.0
N 0 + [$MP_{(N)}$ $Pg_{(0)}$ $Me_{(+)}$]		7.0		0.0
N + + [$MP_{(N)}$ $Pg_{(+)}$ $Me_{(+)}$]		67.0		53.0
ANB	**Range (degree)**	**Treated group, %**	**Control group, %**	**Summary, %**
Worsen	2–3	7.0	10.0	Treated group = 7 Control group = 10
Unchanged	1 < 0 < 1	40.0	63.0	Treated group = 40 Control group = 63
Improvement	1–3	53.0	20.0	Treated group = 53
	>3	0.0	7.0	Control group = 27
Molar relationship	**Range (mm)**	**Treated group, %**	**Control group, %**	**Summary, %**
Worsen	1–3	0.0	3.3	Treated group = 13.3
	1–2	13.3	3.3	Control group = 6.6
Unchanged	1 < 0 < 1	46.7	70.0	Treated group = 46.7 Control group = 70
Improvement	1–2	16.7	20.0	Treated group = 40
	2–3	10.0	0.0	Control group = 23.3
	3–4	10.0	3.3	
	4–5	3.3	0.0	

ANB, A point, nasion, B point; ANB°, Angle between point A-nasion-point B; A, point A, subnasale, the deepest midline point on the anterior outer contour of the maxillary alveolar process; N, nasion, the most anterior point of the frontonasal suture in the midsagittal plane; B, point B, supramentale, the deepest point on the outer contour of the mandible.

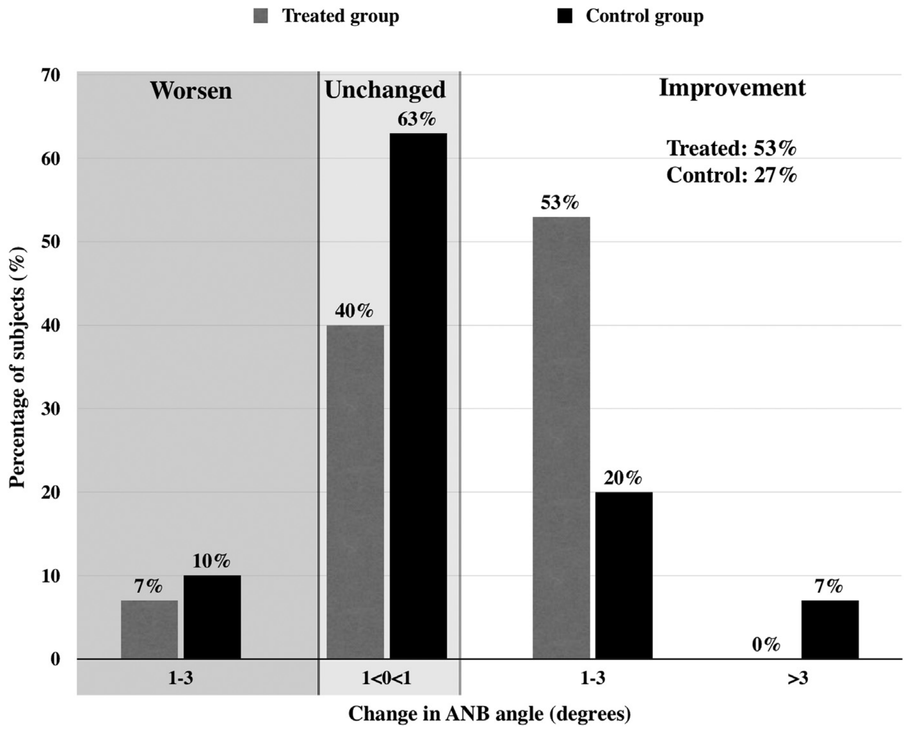

Fig. 5. Categorized changes in jaw base relationship according to ANB-angle.

interference [25], elimination of mandibular restricition due to maxillary widening [26], anterior mandibular posturing after maxillary overexpansion resulting in subsequent mandibular growth [6], and condylar adaptation and modeling [27].

The evaluation of treatment effects was performed in comparison with the untreated Class II control group. The initial age, Tx/observation period, and gender distribution were comparable. Most initial dentoskeletal parameters showed no significant differences between Tx/control groups confirming their comparability; however, facial convexity was more pronounced in the control group, implying some soft tissue differences.

4.1. Skeletal mandibular effect

No additional mandibular growth was found in our study, which is in accordance with other studies after RME treatment [9,10], which contradicts the results of Guest et al. [11] who described significant mandibular effects after pre-pubertal RME treatment.

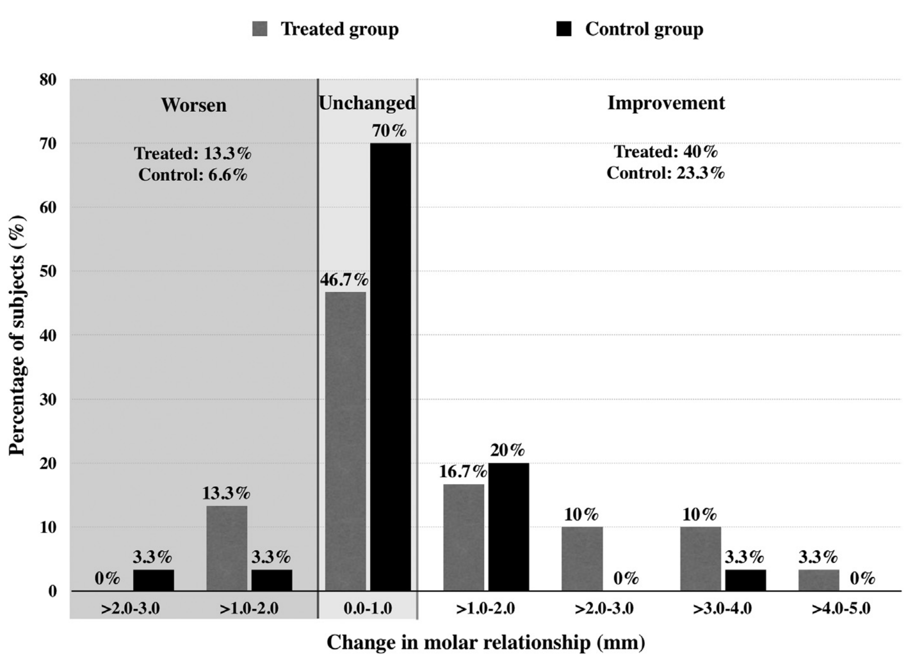

Fig. 6. Categorized changes in molar relationship.

Moreover, deep bite correction has been reported to promote forward growth of B-point without significant change at pogonion and mandibular length [4].

Why optimal coordination of dental arches was not enough to trigger a forward mandibular posturing and through this subsequent mandibular growth [6] or did not act as “endogenous functional appliance” [28] is unknown. It could be speculated that the 6-month observation period was too short, but patients were in acceleration phase of pubertal growth. Also, the 6-month observation period should be sufficient for cellular response for condyle remodeling to occur [29]. Thus, if arch coordination could serve as a Class II corrective trigger, this 6 months should have been enough to at least show a clear trend in terms of group differences.

4.2. Change in sagittal skeletal jaw base relationship

The mean change in ANB-angle was not statistically different between the Tx and control groups in our study. Nevertheless, most of the Tx sample (53%) showed an improvement in ANB-angle by 1 to 3° while most of the controls remained unchanged. This favorable response was due to a significant decrease in SNA-angle in the Tx group, which is in agreement with Wendling et al. [25] In contrast, a decrease in ANB-angle could be due to mandibular changes [11]. As a side effect, the facial convexity angle decreased significantly in the Tx group because backward movement of the subnasale. Thus, the sagittal skeletal jaw base relationship was improved even though retrusion of the chin persisted.

4.3. Changes in class II molar relationship

Previous RME studies revealed 1.4 to 1.8 mm of Class II molar relationship improvement with treatment in comparison with 0.1 to 0.6 mm in the controls [10,11]. The improvement from our study was only 0.8 mm in the Tx group and 0.3 mm in the controls. Although the mean group differences were not significantly different, the percentage of patients showing an improvement were more favorable in the Tx group. Without treatment, our percentages (23% improved, 70% unchanged, 7% worsen) were comparable to the study of McNamara et al. [10] (26%–29% improved, 60%–63% unchanged, 8%–14% worsened). With treatment, the percentage of improvement in our study (40% improved, 47% unchanged, 16% worsened) was lower (69%–81% improved, 17%–30% unchanged, 1%–2% worsened); however, treatments were initiated earlier during mixed dentition and observation time was much longer (~4 years). During this transitional period, 56% of subjects with flush terminal plane relationship could turn into a Class I without treatment [23]. Our study was performed in permanent dentition excluding occlusal changes from utilization of Leeway space. A deterioration in molar relationship was most likely the side effect of maxillary expansion/arch coordination, which may induce clockwise mandibular rotation. In line with the percentage of worsened molar relationships in both groups (7%–10%), we observed 10% of subjects in each groups with a clockwise mandibular growth pattern (B−+).

4.4. Change in mandibular growth patterns

Backward mandibular rotation could inhibit sagittal improvement in Class II patients [30]. However, most of both samples exhibited no rotational change of mandible with forward and downward chin position (N++). The backward rotation with more retruded pogonion position (B−+), which is clearly the most detrimental pattern for Class II patients, was equally frequent (10%) in both Tx and control groups.

5. Conclusion

Upper and lower arch coordination alone does not seem to affect the amount of mandibular growth or the occlusal relationship. The sagittal skeletal jaw base relationship showed more frequent improvements in the treated sample as a result of a decrease in SNA. We could observe a posterior rotation of the mandible with expansion approach increasing facial convexity, which is an undesirable effect in skeletal class II patients.

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Supplementary data

Supplementary data related to this article can be found online at https://doi.org/10.1016/j.ejwf.2019.09.001.

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