Original Article

Occlusal plane canting reduction accompanies mandibular counterclockwise rotation in camouflaging treatment of hyperdivergent skeletal Class II malocclusion

Rui Ye[a]; Yu Li[b]; Xue Li[a]; Juan Li[b]; Jue Wang[a]; Sen Zhao[a]; Zhihe Zhao[c]

ABSTRACT

Objective: To investigate the occlusal configurations of the hyperdivergent skeletal Class II malocclusion and their alterations during the camouflaging treatment in an attempt to identify occlusal changes that might be related to mandibular counterclockwise rotation.

Materials and Methods: Cephalograms of 126 subjects with hyperdivergent skeletal Class II malocclusion and 126 subjects with a clinically normal skeletal pattern were chosen. Several measurements were calculated and compared between the groups. To examine the effects of treatment, two groups were established according to mandibular rotation: counterclockwise rotation (CCR) and the opposite clockwise rotation (CR). After 40 subjects were excluded, the other 86 Class II subjects were assigned to CCR (n = 22) and CR (n = 64). Their pretreatment (T1), posttreatment (T2), and postretention (T3) cephalograms were obtained. Measurement changes (T3-T1) were analyzed in each group and compared between groups.

Results: Compared with the normal skeletal pattern, the cant of the occlusal plane (OP) of the study subjects was significantly steeper and the vertical heights of the incisors were significantly larger for the malocclusion. Compared with the changes in CR, there was a prominent reduction of the OP canting with remarkable intrusion of the maxillary incisor in CCR.

Conclusion: Increased OP canting with overerupted incisors is evident in the hyperdivergent skeletal Class II malocclusion. During the camouflaging treatment, reduction of OP canting could occur. It was accompanied by mandibular counterclockwise rotation and intrusion of the maxillary incisor. (*Angle Orthod.* 2013;83:758–765.)

KEY WORDS: Occlusal plane; Maxillary incisor; Hyperdivergent skeletal Class II malocclusion; Mandibular rotation

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INTRODUCTION

Hyperdivergent skeletal Class II malocclusion has always been a challenge in orthodontics for it is presented with both sagittal and vertical discrepancies. Early interventions such as high-pull headgear,[1,2] Herbst appliance,[3,4] and Von Beek appliance[5] have been reported to be effective, but unfortunately, most patients in China miss the opportunity for early intervention. Meanwhile, although most patients are candidates for orthognathic surgery to obtain satisfying profiles and occlusions, they reject surgery and insist on camouflage treatment.

A successful nonsurgical treatment is supposed to induce a counterclockwise rotation of the mandible, as this rotation is beneficial for correcting either the

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vertical or the sagittal problem. However, it is difficult to achieve. Although the literature abounds with research describing various orthodontic approaches in the camouflaging treatment of hyperdivergent skeletal Class II malocclusion,[2,6–11] few have reported a counterclockwise rotation of the mandible.

The rotation of the mandible is closely related to the alteration of the occlusal plane during growth. Previous studies observed a continuous horizontalization of the occlusal plane accompanied by a simultaneous reduction of the cant of the mandibular plane during growth and development.[12–15] This indicates that changes in the occlusal plane might influence the skeletal frame of the malocclusions. For hyperdivergent skeletal Class II malocclusion, Fushima et al.[16] pointed out that the backwardly rotated mandible was partially accompanied by a steep cant of the posterior occlusal plane with an inadequate vertical height of the upper terminal molars.

As the mutual relationships between the occlusal plane and the mandibular position have been extensively studied, control of the occlusal plane gradually becomes of fundamental interest to orthodontists. By definition, the occlusal plane is a horizontal plane, but its control is in essence the control of the vertical dimensions of dental arches. Opinions diverge in terms of the way vertical dimensions should be managed in treating hyperdivergent skeletal Class II malocclusions. One commonly accepted concept is that vertical height of the molar should be strictly restrained to avoid unfavorable backward rotation of the mandible.[17,18] In contrast, other scholars have reported that elongation of the molars (especially the upper molar) is not detrimental but necessary for the treatment of the maloccusion.[16]

Therefore, the present investigation attempts to solve the dispute from the following aspects: First, what is the difference in occlusal configuration between the hyperdivergent Class II malocclusion and normal skeletal pattern? Second, what type of changes in occlusal configurations would accompany the counterclockwise rotation of the mandible?

MATERIALS AND METHODS

Subjects

The study was approved by the bioethics committee of the university. Files from the Orthodontic Department of West China Dental Hospital were searched for appropriate subjects. The selection criteria included the following: (1) female patients who had completed their nonsurgical treatments with all 4 premolars (maxillary first premolars and either mandibular premolar) extracted; (2) treated by doctoral postgraduate students under the instruction from the same supervisor; (3) nongrowing at the start of the treatment (cervical vertebral maturation CVM5[19]); (4) hyperdivergent Class II skeletal pattern (MP-SN$>36^\circ$, ANB$>4^\circ$, and moderate overbite); (5) mild pretreatment crowding (<4 mm for each arch); (6) dental Class II relationship before treatment; (7) no missing teeth or supernumerary teeth; and (8) no complaints of temporomandibular problems before or after the treatment.

The patients were treated with 0.022*0.028-inch brackets using generally identical treatment modalities. These involved alignment, leveling, and space closure on 0.019*0.025-inch SS archwires (ClassOne Orthodontics, Carlsbad, Calif) using a sliding mechanism. Additional appliances for specific purposes (such as anchorage and incisor intrusion) were used if needed. Other inclusion criteria concerned outcomes after the treatment: (1) Class I molar and canine relationships and (2) normal overbite and overjet.

A total of 136 Class II female patients with a hyperdivergent face type were selected. Ten were excluded because of inadequate cephalometric records or incomplete treatment data. The average age of the 126 patients was 18.3 $\pm$ 2.5 years at pretreatment (T1) and 20.8 $\pm$ 3.0 years at posttreatment (T2). The average posttreatment (T3) interval was 1.2 $\pm$ 0.1 years.

Another 126 adult females with clinically normal skeletal patterns and matched for ages were also selected from the files. Specifically, they had (1) a normodivergent Class I skeletal pattern (MP-SN$>32^\circ$ and $<36^\circ$, ANB$>0^\circ$ and $<4^\circ$, moderate overbite) and (2) mild to medium Class I molar relationships. The average age of the clinically normal subjects was 19.8 $\pm$ 1.9 years.

METHODS

Comparison Between the Normal Group and the Class II Group

The lateral cephalograms of the clinically normal group and those of the Class II group, taken at T1, were obtained. All the radiographs were input into the software of Wincep 7.0 (Rise Corp, Tokyo, Japan), after which cephalometric landmarks were defined as described in Figure 1. Twelve measurements that represented skeletal, dental, and occlusal frames were used.

Comparison Between the Counterclockwise Rotation and the Clockwise Rotation Groups

The lateral cephalograms of the Class II group, taken at T2 and T3, were obtained and digitized by Wincep 7.0. The 126 Class II subjects were then sorted by ΔY-axis angle and ΔMP-SN (Δ stood for net changes resulting from T2 minus T1) as follows: the

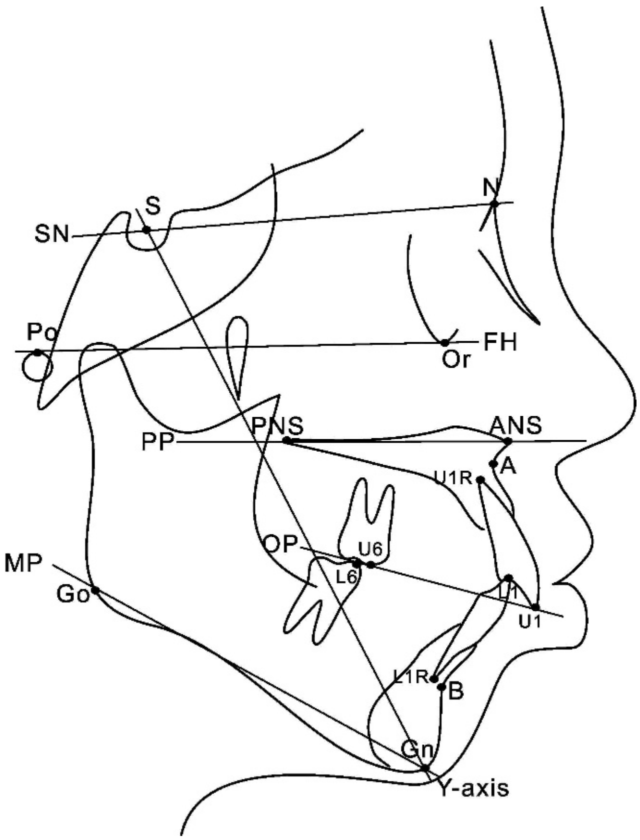

Figure 1. Landmarks, reference planes, and cephalometric measurements used for the study. Skeletal landmarks: S, Sella; N, nasion; Po, porion; Or, orbitale; ANS, anterior nasal spine; PNS, posterior nasal spine; A, subspinale; B, supramental; Gn, gnathion; Go, gonion. Dental landmarks: U1, maxillary incisor tip; U1R, root apex of maxillary incisor; U6, maxillary molar mesial apex; L1, mandibular incisor edge; L1R, root apex of mandibular incisor; L6, mandibular molar mesial apex. Reference planes: SN; FH, Po-Or; PP, ANS-PNS; OP, U1-U6; MP, Go-Gn. Angular measurements: SNA; SNB; ANB; MP-SN; OP-SN; U1-SN, anteroinferior angle formed by SN and U1-U1R; L1-MP, posterosuperior angle formed by MP and L1-L1R. Linear measurements: U1-PP, distance from U1 to PP; U6-PP, distance from U6 to PP; L1-MP, distance from L1 to MP; L6-MP, distance from L6 to MP.

subjects with both ΔY-axis angle and ΔMP-SN $\leq -0.5^\circ$ were assigned to the counterclockwise rotation (CCR) and those with both ΔY-axis angle and ΔMP-SN $\geq 0.5^\circ$ to clockwise rotation (CR). The remaining subjects with either ΔY-axis angle or ΔMP-SN ranging from -0.5° to 0.5° were excluded. The previously described cephalometric analysis was applied.

We next looked through the treatment data for each patient in the CCR and CR groups. According to previous literature, we identified three specified methods for incisor intrusion: the high-pull J-hook headgear, miniscrew, and segmented intrusive arch.[20–23] We subsequently determined the number of subjects that had undergone these three special techniques in each group.

Statistical Analysis

The statistical analysis was performed using SPSS 18.0 for Windows. Descriptive statistics (means and standard deviations) were calculated. For comparison between the clinically normal and the Class II groups, a *t*-test was applied. For comparison between CCR and CR at pretreatment, a *t*-test was applied. Skeletal and dental changes that occurred during treatment (T2-T1), during retention (T3-T2), and across the overall period (T3-T1) were evaluated using a paired *t*-test. Intergroup differences of changes were also tested by a *t*-test. To report differences in the utilization rate of special techniques, a χ^2 test was carried out.

To assess the cephalometric method error, duplicate tracings and measurements of 30 randomly selected lateral cephalograms were made by the same investigator after 10 days. Measurement errors were determined using Dahlberg formula:

$$\sqrt{\sum \frac{d^2}{2n}}$$

where d is the difference between the measured values and n is the number of double measurements. The average measurement errors were 0.3° for angular measurements and 0.4 mm for linear measurements. They were considered within acceptable limits.

RESULTS

Comparison Between the Clinically Normal Group and the Class II Group

Descriptive analysis used for comparison between the clinically normal group and the Class II group is given in Table 1.The mean cant of the occlusal plane in the clinically normal group was 19.2 with a standard deviation of 3.2, and the Class II group demonstrated a significantly steeper cant of occlusal plane. For the dentoalveolar heights, there were statistically significant differences in the vertical heights of the incisors (U1-PP, L1-MP) between the two groups. However, the heights of the molars (U6-PP, L6-PP) were not significantly different. The inclinations of the incisors also appeared more labially inclined in the Class II group. For skeletal parameters, SNA tended to be comparable between the two groups, and SNB was significantly smaller in the Class II group.

Comparison Between CCR and CR

Of the total sample of 126 subjects with hyperdivergent skeletal Class II malocclusions, 40 were excluded because either their ΔY-axis angle or their ΔMP-SN ranged from -0.5° to 0.5°. Among the 86

Table 1. Comparison Between the Clinically Normal Group and the Class II Group

Measurement	Clinically Normal Group (n = 126) Mean	SD	Class II Group (n = 126) Mean	SD	*P*-Value
Occlusal and dental					
OP-SN (°)	19.2	3.2	26.7	4.0	.000***
U1-SN (°)	80.9	6.3	75.6	5.5	.000***
IMPA (°)	95.3	6.0	103.6	6.1	.000***
U1-PP (mm)	26.7	2.9	30.1	3.0	.000***
L1-MP (mm)	39.6	3.2	45.1	3.4	.000***
U6-PP (mm)	22.0	3.1	21.3	2.8	.061
L6-MP (mm)	30.2	3.3	29.8	3.4	.344
Skeletal					
SNA (°)	81.2	3.3	80.6	3.1	.138
SNB (°)	78.4	3.5	74.7	3.5	.000***
ANB (°)	2.8	2.2	5.9	2.4	.000***
MP-SN (°)	32.8	4.3	39.7	5.0	.000***
Y-axis (°)	61.8	3.9	65.3	4.5	.000***

* $P < .05$; ** $P < .01$; *** $P < .001$.

subjects, 22 were assigned to CCR group and the other 64 to the CR group. The chronologic ages at the initiation of the treatment and the treatment duration were similar between the two groups. Cephalometric analysis at T1 showed that only the maxillary incisor was significantly more labially inclined in the CR group, as shown in Table 2. Other parameters were balanced between the two groups.

The changes induced by treatment (T2-T1) are presented in Table 3 and Table 4 for each subgroup. In the CCR group, with the reduction of MP-SN and Y-axis angle, OP-SN was significantly reduced by 0.6°. Meanwhile, the upper and lower incisors were remarkably intruded, but no significant changes were seen in terms of molar heights. In the CR group, the occlusal plane canting was steepened by 1.8° as both MP-SN and the Y-axis angle increased. Concomitantly, the maxillary incisor was marginally extruded while the maxillary molar was almost stable. The mandibular incisor was significantly intruded, but the mandibular molar was marginally extruded.

The posttreatment changes (T3-T2) showed some extrusion of both U1 and L1 in the CCR group (Table 3). However, only L1 was extruded during retention in the CR group (Table 4). No significant changes were observed for other parameters in both groups.

Table 2. Comparison Between the Counterclockwise Rotation (CCR) and Clockwise Rotation (CR) Groups at Pretreatment (T1)

Measurement	CCR Group (n = 22) Mean	SD	CR Goup (n = 64) Mean	SD	*P*-Value
Angular (°)					
SNA	81.0	2.8	80.5	2.1	.381
SNB	74.5	2.3	74.8	2.0	.698
ANB	6.5	1.5	5.7	2.3	.132
MP-SN	40.2	4.7	39.5	5.1	.573
Y-axis	66.0	3.5	65.1	4.1	.36
OP-SN	27.9	3.1	26.3	3.8	.079
U1-SN	77.7	4.0	74.8	5.8	.033*
L1-MP	102.3	5.2	104	6.5	.27
Linear (mm)					
U1-PP	31.0	2.1	29.8	3.3	.115
L1-MP	45.5	2.9	45.0	3.4	.539
U6-PP	21.4	2.1	21.3	2.7	.875
L6-MP	30.2	2.5	29.7	4.0	.584

* $P < .05$.

Table 3. Changes During Treatment (T2-T1), During Retention (T3-T2), and Across the Overall Period (T3-T1) for the Counterclockwise Rotation (CCR) Group

	CCR Group (n = 22)					
	T2-T1		T3-T2		T3-T1	
Measurement	Mean	SD	Mean	SD	Mean	SD
Occlusal and dental						
OP-SN (°)	−0.6**	1.1	0.0	0.6	−0.6**	1.0
U1-SN (°)	5.3***	4.2	−1.3	3.8	4.0***	4.3
IMPA (°)	−9.0***	4.4	1.5	3.6	−7.5***	3.8
U1-PP (mm)	−1.2**	1.7	0.5*	1.1	−0.7*	1.5
L1-MP (mm)	−2.3***	1.9	0.7*	1.3	−1.6**	2.1
U6-PP (mm)	0.2	2.3	0.2	1.2	0.4	2.0
L6-MP (mm)	0.0	2.5	0.3	1.5	0.3	2.4
Skeletal						
SNA (°)	−0.7	2.6	0.0	1.1	−0.7	2.5
SNB (°)	0.5	2.2	−0.1	1.0	0.4	2.7
ANB (°)	−1.2*	2.5	0.1	1.3	−1.1*	2.5
MP-SN (°)	−1.3***	0.7	0.3	1.2	−1***	0.9
Y-axis (°)	−1.9***	1.3	0.3	1.1	−1.6***	1.5

* $P < .05$; ** $P < .01$; *** $P < .001$.

Table 4. Changes During Treatment (T2-T1), During Retention (T3-T2), and Across the Overall Period (T3-T1) for the Clockwise Rotation (CR) Group

	CR (n = 64)					
	T2-T1		T3-T2		T3-T1	
Measurement	Mean	SD	Mean	SD	Mean	SD
Occlusal and dental						
OP-SN(°)	1.8***	2.0	−0.3	1.2	1.5***	1.8
U1-SN(°)	8.3***	3.3	−1.1	3.5	7.2***	3.4
IMPA(°)	−9.3***	5.0	1.3	4.2	−8.0***	5.3
U1-PP(mm)	0.5	2.0	0.1	0.6	0.6*	2.1
L1-MP(mm)	−1.9***	2.5	0.3*	0.9	−1.6***	2.2
U6-PP(mm)	0.5	3.1	0.1	1.1	0.6	3.3
L6-MP(mm)	0.8	3.4	0.0	1.8	0.8	3.5
Skeletal						
SNA(°)	0.2	2.5	−0.2	1.3	0.0	2.8
SNB(°)	−1.2**	3.0	0.0	1.2	−1.2**	2.8
ANB(°)	1.4***	2.7	−0.2	1.0	1.2**	2.9
MP-SN(°)	2.5***	1.3	0.1	1.2	2.6***	1.8
Y-axis(°)	3.0***	2.0	0.0	1.5	3.0***	2.5

* $P < .05$; ** $P < .01$; *** $P < .001$.

The overall changes (T3-T1) of each group (Table 3 and Table 4) exhibited similar trends as that induced by treatment (T2-T1), indicating that although there was some relapse during retention, it was not significant enough to alter the effects of treatment. However, the two groups exhibited significant differences in terms of overall changes on a series of parameters, which are shown in Figure 2.

Treatment data related to the utilization of special techniques for intrusion of the maxillary incisor are shown in Figure 3. The χ^2 test demonstrated significantly higher utilization rates of these techniques in the CCR group ($P < .05$).

DISCUSSION

The skeletal feature of hyperdivergent skeletal Class II malocclusion is not generally characterized by a protruded maxilla, but a backwardly rotated mandible, as corroborated by our and previous findings.[16,24] Therefore, rotating the mandible forward is desired so that both the vertical and the sagittal problems can be somewhat alleviated. To understand the occlusal changes that might have induced CCR of the mandible, we come to a fundamental question: How does the occlusal configuration of the malocclusion deviate from that of the normal skeletal pattern? Our results showed that the hyperdivergent skeletal Class II malocclusion demonstrated a steeper cant of the occlusal plane (SN-OP), which was possibly contributed to by an excessive height of the maxillary incisors. Our findings were quite dissimilar to those of with a previous report that considered the inadequate eruption of the upper molars as a major contributor to the steep cant of occlusal plane.[16] The discrepancy might be derived from a different growth stage of their sample, which retained more growth potential than ours. Moreover, as the malocclusion is usually characterized by an excessive anterior vertical development (lower face height),[16,20] overeruption of the incisors could be considered a compensation.

We next examined the occlusal alterations accompanying forward rotation of the mandible. We grouped the subjects according to the two opposite directions (forward and backward) in which the mandible rotated; subjects whose mandibular rotations were vague and indefinite were excluded. The use of subjects with backward rotation as a negative control allowed for a more rigorous appraisal of therapeutic changes. Among the 86 subjects meeting the criteria, only 32.3% had a forward-rotated mandible. This was in comparison the 67.7% in which the mandible was rotated backward. The unbalance is not unexpected, as a CCR of the mandible is much more difficult to obtain than a CR in clinical settings.

Our findings revealed that the steepness of the occlusal plane (OP) canting was reduced as the mandible rotated forward. Simultaneously, the maxillary incisor was remarkably intruded. Although the vertical height of the maxillary incisor tended to relapse during retention, the amount was insufficient to offset the overall therapeutic results. The association between CCR of the mandible and reduction of OP canting could be interpreted by the hinge structure of the temporomandibular complex. In a case where forward rotation of the mandible occurs, the vertical dimension of the arch that positions anteriorly to the hinge should be minimized to provide space for the rotation. In the present study, the intrusion of the anterior teeth provided the space. The vertical maintenance of the molars and their mesial movement (especially the mandibular teeth) during the process of establishing Class I dental relationship increases the distance from the terminal fulcrum to the hinge and consequently regulates the mandibular inclination by means of a wedge effect.

The data combined suggested that the vertical control of the maxillary incisor seemed to make an ultimate difference in the rotation of the mandible. We thus attempted to preliminarily investigate how it happened. First, the use of intrusive mechanics is necessary as intrusion of the maxillary incisor is hardly possible to obtain by routine treatment procedures, that is, alignment and then leveling and closing the spaces. After defining the commonly used appliances, that is, high-pull J-hook headgear, miniscrews, and segmented intrusive arch,[20–23] we found that they were used much more frequently in CCR. This is possibly of major importance for the prominent intrusion in that group. Second, lingual tipping of the maxillary incisors might have also contributed to the difference. Our findings demonstrated a more pronounced lingual tipping, by approximately 3°, both after treatment and retention in the CR group. Given the pendulum-like effect on vertical dimension caused by lingual retraction of the maxillary incisor, the minimal extrusion of the maxillary incisor in the CR group is partially explained.

The mandibular CCR is beneficial for correcting sagittal discrepancies, as validated by the reduction of ANB angle. However, the excessive ANB angle persisted over the treatment and retention periods, suggesting the limits of nonsurgical treatment on skeletal patterns. Such limits might hopefully be minimized among growing adolescents. As a previous investigation reported,[17] inclination of the occlusal plane could regulate mandibular displacement during growth along its forward and downward vector. If orthodontists correctly flatten the occlusal plane, the vertical component of the growth vector is reduced and the forward component, the so called "mandibular response,"[25]

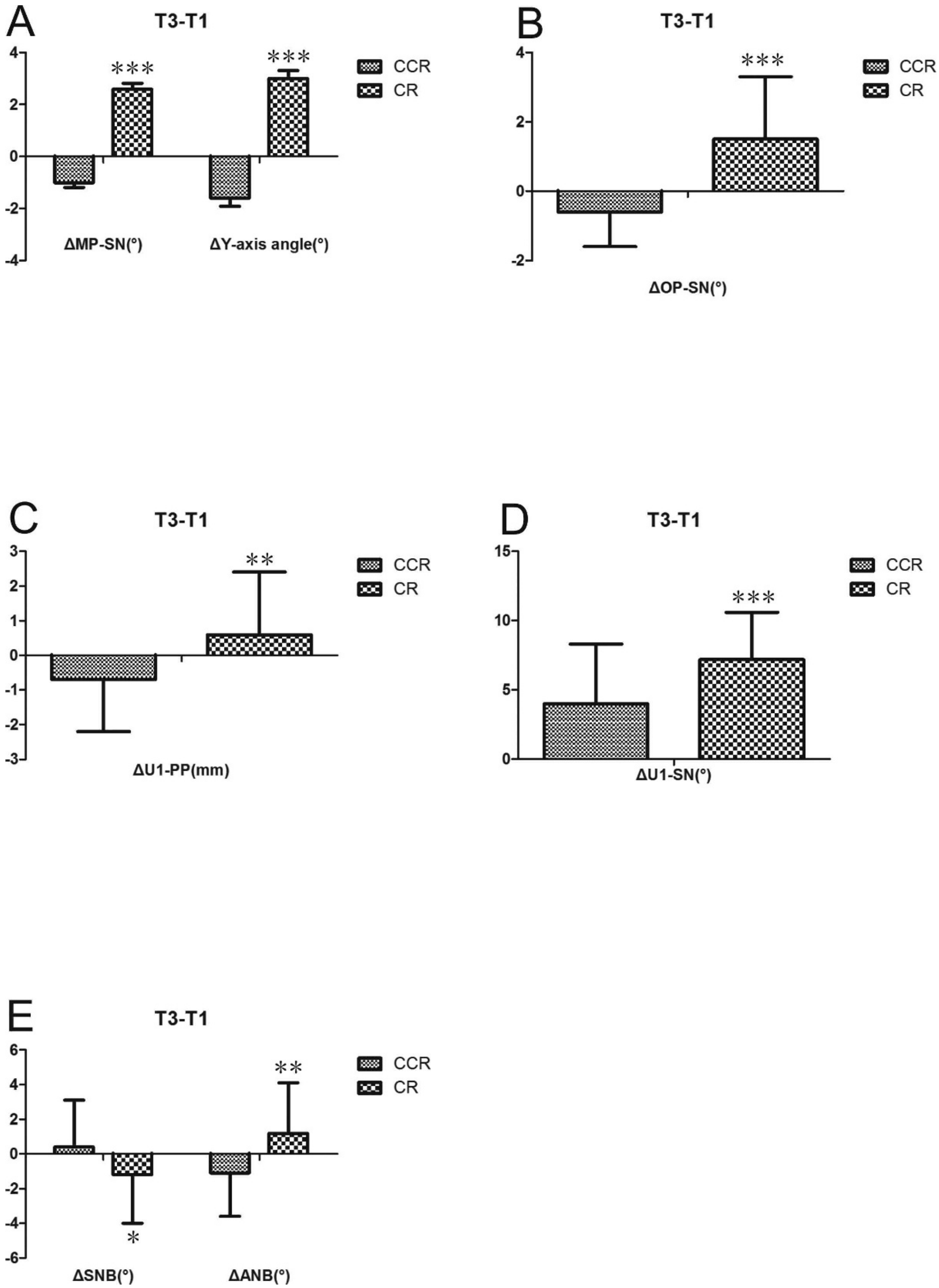

Figure 2. Overall changes (T3-T1) that demonstrated significant differences between the counterclockwise rotation (CCR) and clockwise rotation (CR) groups. Along with the forward and backward rotations of the mandible (A), OP-SN (B), U1-PP (C), SNB and ANB (E) changed in different ways. And U1-SN (D) altered in same way but at different magnitudes. Changes of other unshown measurements did not exhibit significant differences. * $P < .05$; ** $P < .01$, *** $P < .001$. *P* represents differences between the CR and CCR subgroups.

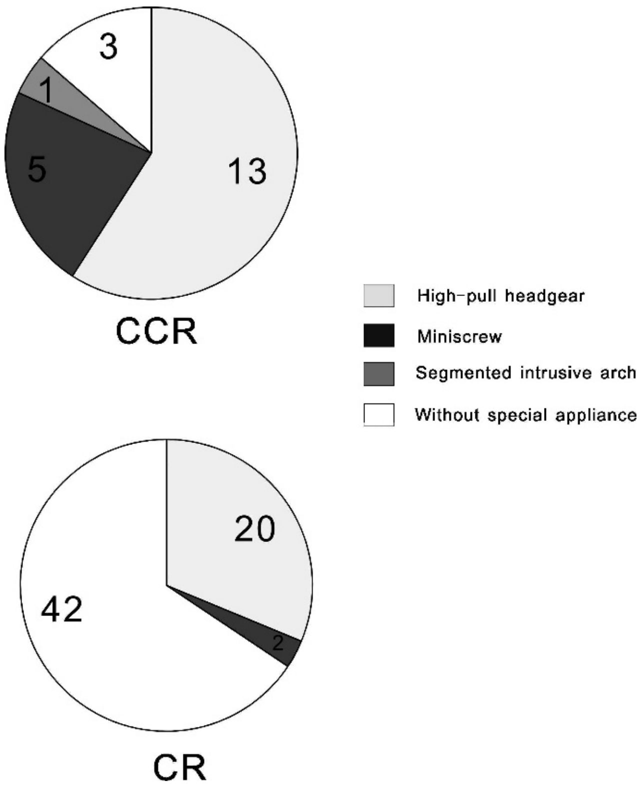

Figure 3. Proportion of cases in which special techniques were adopted to intrude the maxillary incisor in each group. A total proportion of 86.6% in the counterclockwise rotation (CRR) group adopted one technique to intrude the maxillary incisor. However, only 34.4% of the patients in clockwise rotation (CR) group used either one of these techniques.

can be increased. Combined with sufficient growth potential, the sagittal discrepancy of the malocclusion is expected to be maximally corrected.

To summarize, the occlusal canting is steeper for the hyperdivergent skeletal Class II malocclusion and is primarily contributed to by the excessive heights of the incisors. The significance of the present study adds new meanings to the reduction of the occlusal plane canting and the intrusion of anterior teeth in the camouflage treatment of the hyperdivergent Class II malocclusion.

CONCLUSIONS

- The occlusal configuration of the hyperdivergent skeletal Class II malocclusion is characterized by a steeper cant of occlusal plane with overerupted incisors.
- Reduction of occlusal plane canting accompanies mandibular CCR in camouflage treatment of the malocclusion. Intrusion of the maxillary incisor makes a difference during the process.

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