Comparison of Skeletal Changes between Female Adolescents and Adults with Hyperdivergent Class II Division 1 Malocclusion after Orthodontic Treatment

Yun DING[1], Jian Hui ZHAO[2], Jin Rong DENG[1], Xiu Jing WANG[3]

Objective: *To compare the skeletal changes between female hyperdivergent adolescents and adults with Class II Division 1 malocclusion after orthodontic treatment.*
Methods: *Thirty adolescent girls and 30 adult women both with hyperdivergent Class II Division 1 malocclusions were selected. The 2 groups were matched by both treatment period and treatment method. Cephalometric radiographs taken before and after treatment were traced and measured. Data were statistically examined.*
Results: *After treatment, SNA decreased significantly in both groups. SNB remained unchanged in the adolescent group, while it decreased in the adult group. ANB decreased significantly only in the adolescent group and remained unchanged in the adult group. Obvious growth was found in the adolescent group. Ar-Gn, Ar-Go, N-Me and S-Go increased significantly in adolescents. In the adult group, N-Me and ANS'-Me increased after treatment, but with less magnitude than those in the adolescent group. All the angular measures (MP-SN, PP-SN, Ar-Go-Gn and N-S-Ba) remained quite stable in both the adolescent and adult groups.*
Conclusion: *Although obvious vertical growth was found in the female hyperdivergent adolescent Class II Division 1 group, no clockwise rotation of the mandible and no mandibular catch-up growth were found. Vertical growth of the mandible was helpful in maintaining the MP-SN angle with conventional orthodontic mechanism in the adolescent group.*

Key words: *Class II Division 1 malocclusion, hyperdivergent, cephalometric analysis, skeletal changes, vertical growth*

The Class II Division 1 malocclusion is a frequently encountered challenge in clinical practice[1,2]. For adults without growth potential, the sagittal discrepancies are mainly corrected by dental compensation, while for adolescents, growth plays an important role in successful treatment. For example, favourable mandibular growth may assist in the anteroposterior correction, while unfavourable growth may even increase the difficulty of the Class II correction or even make it impossible to accomplish without surgical intervention. So, the knowledge of the direction and magnitude of growth is really very important for successfully treating adolescents.

So far, it has been discussed a lot in the literature but there is still a lack of common agreement on the role of mandibular growth on the correction of Class II malocclusion in adolescents[3–7]. Some researchers have shown that the mandible grows faster than the maxilla, which helps in the correction of skeletal Class II relationship in adolescents[4], while others found that mandibular growth does not have any effect on sagittal correction of class II malocclusion and the sagittal discrepancy may even worsen with growth[5]. One of the reasons why

1 Department of Orthodontics, The 3rd Dental Center, Peking University School and Hospital of Stomatology, Beijing, P.R. China.
2 Department of Orthodontics, The 2nd Dental Center, Peking University School and Hospital of Stomatology, Beijing, P.R. China.
3 Department of Orthodontics, The 1st Dental Center, Peking University School and Hospital of Stomatology, Beijing, P.R. China.

Corresponding author: Dr Yun DING, Department of Orthodontics, The 3rd Dental Center, Peking University School and Hospital of Stomatology, Gold Plaza A308, #10 Huayuan East Road, Beijing 100191, P.R. China. Tel: 86-10-82037073; E-mail: yunding666@126.com

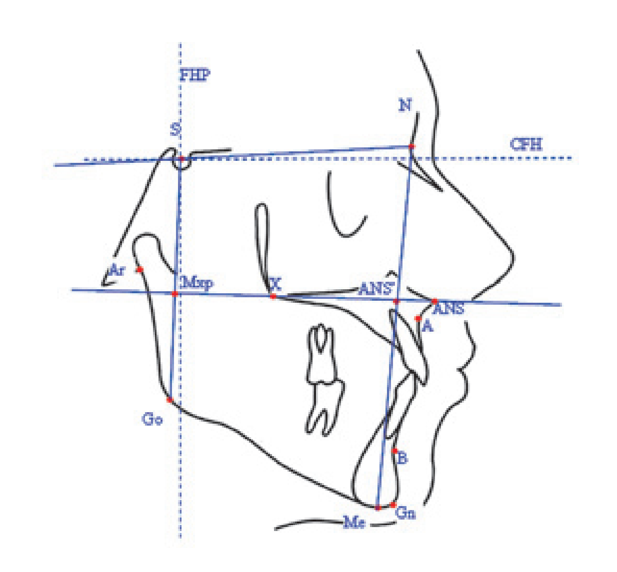

Fig 1 Cephalometric analysis.

different opinions exist regarding mandibular growth is that Class II malocclusion is not only accompanied with anteroposterior discrepancy, but it also has a broad variation in the vertical facial type (low-, average- and high-mandibular angle). Since the mandible growth pattern of the different vertical types is different, it will be necessary to separate the Class II sample according to the vertical skeletal patterns.

The purpose of this study was to investigate mandibular growth changes in female hyperdivergent Class II Division 1 adolescent subjects after orthodontic treatment.

Material and methods

In this study, 60 female patients with hyperdivergent Class II Division 1 malocclusion were selected from dental branches of Peking University School and Hospital of Stomatology. The patients were divided into adolescent and adult groups. The adolescent group consisted of 30 female adolescent patients at peak pubertal growth (skeletal maturation stage CS3–CS4, as determined by cervical vertebral maturation [CVM] method) whose mean age was 12 years and 6 months. The average treatment time was 2 years and 6 months. The adult group consisted of 30 female adult patients in a range of 20 to 40 years old with a mean age of 24 years and 6 months. No growth potential was shown according to the cervical vertebral maturation method. The average treatment time was the same as the adolescent group. The two groups were matched both in treatment method and treatment time.

The following criteria were assumed for patient selection:

1. Skeletal Class II malocclusion (ANB > 5 degrees) with a high mandibular plane angle (MP-SN > 38 degrees)
2. Dental Class II Division 1 malocclusion, distal molar relationship, overjet was greater than 5 mm, mild crowding on the upper arch. After treatment, the molar relationship changed to Class I and overjet decreased to 3 mm.
3. All patients were treated with conventional orthodontic mechanics using a full preadjusted edgewise appliance with MBT prescription, 0.022” slot size bracket. Upper first premolar and lower first or second premolar were extracted. The two groups shared an equal proportion of lower first and second premolar extraction cases. Class II elastics or posterior crossbite elastics were used when necessary. No intrusive mechanics, such as posterior bite-blocks or additional measures to control molar extrusion, such as Nance arch, or a transpalatal bar were used. No patients received skeletal anchorage devices.
4. No temporomandibular joint diseases or other systematic history, no orthodontic treatment history.

Cephalometric analysis

Lateral cephalograms were taken before and after treatment according to the same guideline. The radiographs were traced by one of the investigators and checked by another. In order to reduce the observer’s error, all radiographs were retraced four weeks later by the same investigator. If there was a marked difference between the two measurements, this procedure was repeated for the third time and the mean value of the closest two observed readings was adopted. The error for linear and angular measurements of cephalometric analysis was measured using Dahlberg’s formula. The linear measurement error was averaged to be 0.5 mm and 0.5 degrees for angular measurement. All the linear parameters were corrected by magnification.

A well-known method of measuring craniofacial dimensions in a system with sagittal and vertical axes is used in this study[7]. The horizontal axis (CFH plane) was constructed through sella at an angle of 7 degrees to the SN-line and the vertical axis (FHp plane) was perpendicular to the CFH plane through sella.

The following landmarks (Fig 1) were used in this study:

S (sella), N (nasion), Ar (articulare), A (point A), B (point B), Me (menton), Gn (gnathion), Go (gonion), ANS (anterior nasal spine), ANS' (crosspoint between N-Me and palatal plane), PNS (posterior nasal spine), X (perpendicular point dropped from Ptm on the palatal plane).

The cephalometric planes used are as follows:

- CFH plane: a horizontal plane crossing S and 7 degrees downwards away from SN.
- FHp plane: a vertical plane crossing S and perpendicular to CFH plane.
- PP plane: a plane connecting ANS and PNS
- MP plane: a plane connecting Gn and Go.

The following measurements were used: SNA (degrees); SNB (degrees); ANB (degrees); A-FHp (mm); PP-SN (degrees); MP-SN (degrees); PP-MP (degrees); Ar-Go-Gn (degrees); N-S-Ba (degrees); N-Me (mm); ANS'-Me (mm); ANS'-Me/N-Me, S-Go (mm); Go-Mxp (mm); Go-Mxp/S-Go, S-Go/N-Me, (ANS-FHp)-(X-FHp) (mm); Ar-Gn (mm); Ar-Go (mm); Go-Gn (mm).

Statistical analysis

The data were analysed using the Statistical Package for Social Science version 12.0 (SPSS). Descriptive analysis was performed to calculate the mean and the standard deviation in the two groups before and after treatment. Repeated measures analysis of variance and paired *t* tests were carried out for all linear and angular measurement to determine whether they were within acceptable limits. The significance of differences was predetermined at $P < 0.05$.

Results

The linear and angular measurements and the relevant statistics were presented in Tables 1 and 2.

Changes in sagittal direction

After treatment, SNA decreased significantly in both groups ($P < 0.05$), but without difference between the two groups ($P > 0.05$); SNB showed no change in the adolescent group ($P > 0.05$), whereas SNB decreased significantly in the adult group ($P < 0.05$); ANB decreased significantly in adolescents ($P < 0.05$), but remained unchanged in adults ($P > 0.05$); maxillary length increased significantly ($P < 0.05$); while the mandibular corpus remained unchanged in adolescents ($P > 0.05$).

Changes in vertical direction

Obvious vertical growth was found in the adolescent group. Anterior facial height, lower anterior facial height, posterior facial height and lower posterior facial height increased significantly. S-Go/N-Me and Go-Mxp/S-Go remained unchanged ($P > 0.05$), while ANS'-Me/N-Me increased after treatment in the adolescent group ($P < 0.05$). Total mandibular length and the ramus height increased significantly in the adolescent group ($P < 0.05$). In the adult group, N-Me and ANS'-Me increased after treatment ($P < 0.05$), but with less magnitude than those in the adolescent group ($P < 0.05$).

All the angular measures (MP-SN, PP-SN, Ar-Go-Gn and N-S-Ba) remained quite stable both in the adolescent and adult groups and no significant difference was shown between the two groups ($P > 0.05$).

Discussion

So far, the influence of mandibular growth on hyperdivergent sagittal discrepancy of Class II still remains unclear[8–11]. Traditionally, high angle cases are believed to be 'backward rotators', which means vertical growth is more obvious and the mandible rotates clockwise. In the case of Class II malocclusion, backward rotation of mandible will enhance the severity of sagittal discrepancy and make the facial profile more convex[12]. Nagan et al[3] reported that both SNA and SNB decreased with age and ANB increased in skeletal Class II girls with a high-angle. On the other hand, other researchers hold different opinions. Chung et al[7] reported that mean SNB increased and the mean ANB became smaller in untreated Class II malocclusion even with a high mandibular angle. Our data showed that in the adolescent group SNA decreased, which was the combined result of distal movement of upper incisors and forward growth of the maxilla. But the total amount of change of SNA was similar to that of the adult group. SNB increased in the adolescent group, while it decreased in the adult group. A significant difference was found between these two groups. In total, ANB reduced separately by 0.58 degrees in the adolescent group and 0.20 degrees in the adult group, but no significant difference was found between the two groups. So in the present study no mandibular catch-up growth was found in hyperdivergent female adolescents. Sagittal discrepancy is mainly corrected by dental compensation, which is similar to adolescent Class II malocclusion with an

Table 1 Skeletal changes before and after treatment in hyperdivergent adolescent and adult groups

Measurement	Adolescent		P	Adult		P
	Pre-treatment Mean ± SD	Post-treatment Mean ± SD		Pre-treatment Mean ± SD	Post-treatment Mean ± SD	
Sagittal						
SNA (degrees)	82.53 ± 2.95	82.07 ± 3.22	0.04	82.88 ± 3.04	82.22 ± 2.95	0.01
SNB (degrees)	74.44 ± 3.01	74.56 ± 3.15	0.37	74.67 ± 3.16	74.22 ± 2.98	0.03
ANB (degrees)	8.09 ± 1.22	7.51 ± 1.58	0.01	8.21 ± 1.45	8.00 ± 1.20	0.32
A-FHp (mm)	61.39 ± 3.27	61.86 ± 2.99	0.38	63.02 ± 3.80	62.35 ± 3.85	0.31
(ANS-FHp)-(X-FHp) (mm)	49.66 ± 1.96	50.78 ± 2.42	0.00	48.26 ± 1.97	48.27 ± 2.22	0.96
Go-Gn (mm)	67.80 ± 3.06	68.63 ± 2.48	0.08	68.26 ± 3.57	68.60 ± 3.70	0.31
Vertical						
PP-SN (degrees)	8.76 ± 3.22	8.46 ± 3.06	0.53	7.09 ± 4.22	7.19 ± 3.51	0.88
MP-SN (degrees)	43.11 ± 2.90	42.31 ± 3.33	0.20	41.14 ± 4.43	41.67 ± 5.53	0.42
PP-MP (degrees)	34.23 ± 2.77	33.74 ± 3.12	0.17	34.05 ± 5.03	34.48 ± 4.75	0.09
Ar-Go-Gn (degrees)	129.05 ± 3.49	129.16 ± 3.21	0.74	125.99 ± 4.78	126.17 ± 4.22	0.74
N-S-Ba (degrees)	159.96 ± 2.09	159.92 ± 2.30	0.77	159.39 ± 1.99	159.30 ± 1.99	0.60
N-Me (mm)	115.44 ± 4.88	117.93 ± 3.81	0.00	118.61 ± 6.87	119.66 ± 6.65	0.00
ANS'-Me (mm)	62.70 ± 3.83	64.65 ± 3.16	0.00	65.36 ± 4.94	66.07 ± 4.95	0.00
ANS'-Me/N-Me	0.54 ± 0.01	0.55 ± 0.01	0.00	0.55 ± 0.02	0.55 ± 0.02	0.38
S-Go (mm)	65.53 ± 2.94	67.25 ± 2.53	0.00	68.99 ± 4.75	69.22 ± 5.22	0.50
Go-Mxp (mm)	27.01 ± 1.80	28.24 ± 2.46	0.00	29.65 ± 3.35	29.74 ± 3.82	0.79
Go-Mxp/S-Go	0.41 ± 0.03	0.42 ± 0.03	0.10	0.43 ± 0.03	0.43 ± 0.04	0.92
S-Go/N-Me	0.57 ± 0.02	0.57 ± 0.02	0.30	0.58 ± 0.04	0.58 ± 0.03	0.15
Ar-Gn (mm)	94.95 ± 3.93	96.65 ± 2.81	0.00	96.11 ± 4.20	96.33 ± 4.12	0.55
Ar-Go (mm)	36.40 ± 1.98	37.41 ± 2.44	0.01	38.60 ± 3.50	38.38 ± 3.30	0.62

average mandibular angle, as shown in our previous study[13].

Mandibular rotation is of great concern in Class II patients with a high mandibular plan angle[12,14,15]. In our study, obvious vertical growth was found in the adolescent group. Both anterior facial height and posterior facial height increased significantly, with lower anterior and posterior facial height taking dominance. Using S-Go/N-Me as an indicator of mandibular rotation, which has been suggested by Bjork and Skieller[16], we found that S-Go/N-Me remained quite stable and no backward rotation of the mandible was shown in the hyperdivergent adolescent group. On the other hand, even the MP-SN angle of our female adolescent group reduced significantly by 0.8 degrees during orthodontic treatment, but no significant difference was found. So, our data do not agree with those of Ngan et al[3], who reported an increase of MP-SN in skeletal Class II girls. Our data supported previous studies by Karlsen[14,15], Bjork et al[16] and Chung et al[7]. Karlsen in his study of craniofacial growth in untreated high angle adolescents found that the MP-SN angle decreased. In Bjork's growth study, 19 of 21 hyperdivergent subjects had decreased MP-SN angles and they considered backward total rotation in a case of long face syndrome an extreme example of normal variation. Chung's study

Table 2 Comparison of skeletal changes before and after orthodontic treatment between hyperdivergent adolescent and adult groups

Measurement	Treatment change		P
	Adolescent Mean ± SD	Adult Mean ± SD	
Sagittal			
SNA (degrees)	-0.45 ± 1.17	-0.65 ± 1.30	0.53
SNB (degrees)	0.12 ± 0.74	-0.45 ± 1.08	0.02
ANB (degrees)	-0.58 ± 1.05	-0.20 ± 1.11	0.19
A-FHp (mm)	0.47 ± 2.93	-0.67 ± 3.53	0.18
(ANS-FHp)-(X-FHp) (mm)	1.12 ± 1.98	0.01 ± 1.30	0.01
Go-Gn (mm)	0.83 ± 2.51	0.34 ± 1.78	0.38
Vertical			
PP-SN (degrees)	-0.31 ± 2.60	0.10 ± 3.61	0.62
MP-SN (degrees)	-0.80 ± 3.31	0.53 ± 3.57	0.14
PP-MP (degrees)	-0.49 ± 1.94	0.43 ± 1.36	0.04
Ar-Go-Gn (degrees)	0.12 ± 1.86	0.18 ± 2.88	0.93
N-S-Ba (degrees)	-0.04 ± 0.73	-0.08 ± 0.84	0.83
N-Me (mm)	2.49 ± 2.47	1.06 ± 1.70	0.01
ANS'-Me (mm)	1.95 ± 1.75	0.71 ± 1.14	0.00
ANS'-Me/ N-Me	0.0051 ± 0.0063	0.001 ± 0.0064	0.02
S-Go (mm)	1.72 ± 1.80	0.23 ± 1.85	0.00
Go-Mxp (mm)	1.22 ± 1.95	0.09 ± 1.78	0.02
Go-Mxp/ S-Go	0.01 ± 0.02	0.00 ± 0.02	0.18
S-Go/N-Me	0.00 ± 0.01	0.00 ± 0.01	0.08
Ar-Gn (mm)	1.71 ± 2.24	0.22 ± 1.99	0.01
Ar-Go (mm)	1.02 ± 1.88	-0.22 ± 2.45	0.03

showed that the mandible underwent a forward rotation in all high-, average-, and low-angle groups; just the high-angle group had the smallest forward rotation. In Chung's study, untreated hyperdivergent Class II malocclusion patients were selected, while in this study, hyperdivergent Class II patients treated with conventional orthodontic mechanics were selected. Our data suggested that in treating a hyperdivergent Class II patient, the MP-SN angle would most likely decrease with mandibular growth if orthodontic mechanics do not extrude the posterior teeth.

As for the adult group, MP-SN increased, not decreased, by 0.53 degrees after treatment, even though the change of MP-SN was statistically different. Lower anterior facial height and total anterior facial height increased significantly after treatment. It is interesting to note that even though the same conventional mechanics were applied to both groups, vertical dimension control in the adult group was not as good as that in the adolescent group.

Researchers have disputed whether conventional orthodontics can significantly influence vertical dimensions by demonstrating that some of the conventional 'extrusive' treatment mechanics are not contraindicated in hyperdivergent patients, since they produce similar results compared with 'intrusive' protocols[17,18].

Recently, Gkantidis et al[19] compared the different influence of 'intrusive' and 'extrusive' mechanics on vertical dimension in adolescent hyperdivergent Class II Division 1 malocclusion; they found that conventional 'extrusive' mechanics is very limited in significantly altering skeletal vertical dimensions. A similar result was also found in our adolescent group with vertical growth potential. However, in the adult group without growth potential, our data showed that conventional mechanics was not enough for a good control of vertical changes. These data remind us that during orthodontic treatment in adult patients, intrusive forces are necessary to apply in order to enhance the control of posterior dentoalveolar increase and maintain MP-SN. One of the most often used techniques during class II malocclusion treatment is Class II elastics. Though they benefit the correction of a Class II molar relationship, one of the side effects of molar extrusions will cause backward mandibular rotation[20], particularly in the absence of favourable mandibular growth. Similar results were found in our adult group. Therefore, long Class II elastics that can reduce the vertical force are recommended for adult Class II patients. Several other strategies, such as high-pull headgear, Nance appliance, palatal bar, posterior bite block, and also TAD technique to control vertical molar movement or even intrude molars, was proposed to control vertical dimensions in hyperdivergent patients.

Conclusion

1. Obvious vertical growth was found in the adolescent group, but no clockwise rotation of the mandible was found; on the contrary, MP-SN decreased.
2. Obvious mandibular growth did not enhance the sagittal discrepancy. No catch-up growth of the mandible in the hyperdivergent Class II Division 1 adolescent group was found.
3. Vertical growth in the hyperdivergent adolescent group is helpful in maintaining the MP-SN angle with a conventional orthodontic mechanism, while in the adult group more intrusive force is needed to fully control the increase of posterior dentoalveolar and then maintain the vertical dimension in order to guarantee the treatment result of skeletal Class II subjects.

References

1. Bishara SE, Jakobsen JR, Vorhies B et al. Changes in dentofacial structures in untreated Class II division 1 and normal subjects: a longitudinal study. Angle Orthod 1997;67:55–66.
2. Lux CJ, Burden D, Conradt C et al. Age-related changes in sagittal relationship between the maxilla and mandible. Eur J Orthod 2005;27:568–578.
3. Ngan PW, Byczek E, Scheick J. Longitudinal evaluation of growth changes in Class II division 1 subjects. Semin Orthod 1997;3:222–231.
4. Stahl F, Baccetti T, Franchi L et al. Longitudinal growth changes in untreated subjects with Class II Division 1 malocclusion. Am J Orthod Dentofacial Orthop 2008;134:125–137.
5. McKinney JR, Harris EF. Influence of patient age and sex on orthodontic treatment: evaluations of Begg lightwire, standard edgewise, and straightwire techniques. Am J Orthod Dentofacial Orthop 2001;120:530–541.
6. Baccetti T, Franchi L, McNamara JA, Jr et al. Early dentofacial features of Class II malocclusion: a longitudinal study from the deciduous through the mixed dentition. Am J Orthod Dentofacial Orthop 1997;111:502–509.
7. Chung CH, Wong WW. Craniofacial growth in untreated skeletal Class II subjects: a longitudinal study. Am J Orthod Dentofacial Orthop 2002;122:619–626.
8. Baccetti T, Stahl F, McNamara JA Jr. Dentofacial growth changes in subjects with untreated Class II malocclusion from late puberty through young adulthood. Am J Orthod Dentofacial Orthop 2009;135:148–154.
9. Woods MG. Sagittal mandibular changes with overbite correction in subjects with different mandibular growth directions: late mixed-dentition treatment effects. Am J Orthod Dentofacial Orthop 2008;133:388–394.
10. Sankey WL, Buschang PH, English J et al. Early treatment of vertical skeletal dysplasia: the hyperdivergent phenotype. Am J Orthod Dentofacial Orthop 2000;118:317–327.
11. Rothstein T, Phan XL. Dental and facial skeletal characteristics and growth of females and males with Class II Division 1 malocclusion between the ages of 10 and 14 (revisited). Part II. Anteroposterior and vertical circumpubertal growth. Am J Orthod Dentofacial Orthop 2001;120:542–555.
12. Schuddy FF. The rotation of the mandible resulting from growth: Its implications in orthodontic treatment. Angle Orthod1965;35:36–50.
13. Zhao JH, Ding Y. A comparison of skeletal chagnes between adult and adolescent with skeletal Class II malocclusion before and after therapy (in Chinese). Beijing Da Xue Xue Bao 2010;42:578–581.
14. Karlsen AT. Craniofacial growth differences between low and high MP-SN angle males: a longitudinal study. Angle Orthod 1995;65:341–350.
15. Karlsen AT. Association between facial height development and mandibular growth rotation in low and high MP-SN angle faces: a longitudinal study. Angle Orthod 1997;67:103–110.
16. Skieller V, Björk A, Linde-Hansen T. Prediction of mandibular growth rotation evaluated from a longitudinal implant sample. Am J Orthod 1984;86:359–370.
17. Darendeliler N, Taner-Sarisoy L. The influence of orthodontic extraction treatment on dental structures: a two-factor evaluation. Eur J Orthod 2001;23:295–303.
18. Ozaki T, Ozaki S, Kuroda K. Premolar and additional first molar extraction effects on soft tissue. Effects on high Angle Class II division 1 patients. Angle Orthod 2007;77:244–253.
19. Gkantidis N, Halazonetis DJ, Alexandropoulos E et al. Treatment strategies for patients with hyperdivergent Class II Division 1 malocclusion: is vertical dimension affected? Am J Orthod Dentofacial Orthop 2011;140:346–355.
20. Bishara SE. Class II Malocclusions: Diagnostic and Clinical Considerations With and Without Treatment. Seminars in Orthodontics 2006;12:11–24.