Comparison of Cephalometric Measurements among 3 Orthodontic Treatment Methods for Class II Division 1

การเปรียบเทียบวิธีการวัดฟิล์มเซฟาโลเมตริกของการรักษาทางทันตกรรมจัดฟันในผู้ป่วยที่มีการสบฟันผิดปกติชนิดที่ 2 แบบที่ 1

Watjakorn Suadee (วัจน์กร เสือดี)* Smorntree Viteporn (สมรตรี วิถีพร)**

ABSTRACT

The purpose of this study was to compare the differences of cephalometric analysis methods between x-y coordinate superimposition system and conventional (linear and angular analysis) method in Class II division 1 patients treated by different modalities. The sample was retrospectively obtained from pre- and post-treatment lateral cephalograms of Class II, division 1 malocclusion consisting of 96 growing patients (48 boys, 48 girls). Skeletal and dental cephalometric measurements were analyzed and compared by two measurement methods among three groups (headgear, extraction, Class II traction). The changes of SNA, SNB and ANB angles were not significantly different among groups by linear and angular method. However, x-y coordinates superimposition method showed that the chin position in the x axis of headgear group was significantly different in the most forward position compared to Class II traction and extraction group. The different methods of cephalometric analysis affect the results of measurement.

บทคัดย่อ

การศึกษานี้มีวัตถุประสงค์เพื่อเปรียบเทียบความแตกต่างของวิธีการวัดฟิล์มเซฟาโลเมตริกที่ใช้ทางทันตกรรมจัดฟันระหว่างวิธีวัดแบบแกน x-y ซึ่งทำโดยการซ้อนทับภาพกะโหลกศีรษะ และวิธีการวัดแบบมุม และระยะทาง ในคนไข้ที่มีการสบฟันผิดปกติ แบบที่สอง ดิวิชั่นหนึ่ง ด้วยการรักษาที่แตกต่างกัน กลุ่มตัวอย่างได้จาก การเก็บฟิล์มเซฟาโลเมตริกย้อนหลัง ก่อนการรักษา และหลังการรักษาเป็นจำนวน 96 คน (ชาย 48 คน และ หญิง 48 คน) ซึ่งมีการสบฟันผิดปกติชนิดที่สอง ดิวิชั่นหนึ่ง ค่าจากการวัดกะโหลกศีรษะและฟัน ถูกนำมาเปรียบเทียบทั้งสามกลุ่ม (เฮดเกียร์ การถอนฟัน การดึงคลาสทู) ระหว่างวิธีการวัดแบบแกน x-y ซึ่งทำโดยการซ้อนทับ ภาพกะโหลกศีรษะ และการวัดมุมและระยะทาง การศึกษานี้พบว่าการเปลี่ยนแปลงของมุม SNA SNB และ ANB ไม่มีความแตกต่างกันอย่างมีนัยสำคัญระหว่างกลุ่ม ในขณะที่วิธีวัดแบบแกน x-y ซึ่งทำโดยการซ้อนทับภาพกะโหลกศีรษะ แสดงให้เห็นว่า จุด pogonion menton และ B ของกลุ่มเฮดเกียร์ มีการเปลี่ยนแปลงมาด้านหน้ามากกว่าอย่างมีนัยสำคัญ เมื่อเทียบกับอีกสองกลุ่ม จึงสรุปได้ว่าวิธีการวัดฟิล์มเซฟาโลเมตริกมีผลต่อการวิเคราะห์ผลการรักษา

Keywords: Cephalometric film, Superimposition, Orthodontic measurement

คำสำคัญ: ฟิล์มเซฟาโลเมตริก การซ้อนทับภาพรังสี การวัดทางทันตกรรมจัดฟัน

*Student, Higher Graduate Diploma of Clinical Sciences Program in Orthodontics, Department of Orthodontics, Faculty of Dentistry, Chulalongkorn University

**Professor, Department of Orthodontics, Faculty of Dentistry, Chulalongkorn University

Introduction

Cephalometric analysis is the essential part of diagnostic and treatment planning in orthodontics. Various angular and linear measurements created by plotting a set of landmarks and anatomical planes on each radiograph have been used for evaluate the sagittal apical base relationship, for example, SNA, SNB, ANB angles, and Wits appraisal. Each variables have both advantages and disadvantages.

SNA, SNB and ANB angles are frequently used to measure relative jaw relationships in most of the cephalometric analysis. Orthodontist can easily measure in the cephalometric film by the cephalometric ruler and the magnification of the film does not affect the degree of each angle. However, ANB angle does not take the cranial reference planes to evaluate the relative relationship of the denture bases. Moreover, SNA, SNB and ANB angles can be effected by the antero-posterior position of point N (Jacobson, 1975) or by the occlusal plane which subject to growth changes independent of the forward or backward jaw rotation. (Hussels and Nanda, 1984)

To evaluate the effect of orthodontic treatment, it can be compared between cephalometric variables pre- and post-treatment although the superimposition a series of lateral cephalograms is the other method to notice the changes causing by growth and/or treatment. Broadbent was the first to present a standardised cephalometric technique which was useful for superimposition of cephalometric films by tracing on relatively stable or regional contours as reference. (Broadbent, 1981) This method can make the orthodontist know the different effects on each structure.

Class II malocclusion can be treated by many different modalities e.g. headgear, extraction, and using of Class II elastic. The suitable methods of measurement are essential to perceive the different effects of each treatment modalities that reduce the discrepancy between the skeletal bases. So far, there was no comparison study on the effect of the method of measurement upon orthodontic treatment change.

Objective of the study

The aim of this study was to compare the differences of cephalometric analysis methods between x-y coordinate system and conventional (linear and angular analysis) method in Class II division 1 patients treated by 3 different modalities.

Materials and methods

The study sample was retrospectively obtained from pre-treatment and post-treatment lateral cephalograms of Class II, division 1 malocclusion Thai patients who were treated by the second author. The sample comprised 96 growing patients (48 boys, 48 girls) who presented with Class II molar relationship which varied from one half to one premolar width.

Three treatment modalities which had been used were: 1. cervical headgear; 2. extraction of four bicuspids; and 3. Class II traction. The inclusion criteria were: Class II, division 1 malocclusion with a molar class II relationship and an overjet > 3 mm; absence of congenital syndromes or defects, obvious facial asymmetry, extreme vertical disproportion or congenitally missing teeth; a complete orthodontic record indicating patient history, age, sex, type of treatment, lateral cephalograms taken before treatment (T1) and after treatment (T2) from the same radiographic machine; treatment by one of the three following treatment protocols.

The 96 patients were in three groups:

Group 1 : 32 patients (16 boys, 16 girls) mean age 10.8 years. Orthopedic treatment with cervical headgear was followed by fixed appliances using the edgewise technique. Each patient was in the mixed dentition with unerupted permanent maxillary second molars. Analysis indicated skeletal Class II normal or deep bite malocclusion due to maxillary protrusion with severe upper incisor protrusion. The patients were recommended to wear cervical headgear that delivered 500 grams per side via the permanent maxillary first molars for 12 - 14 hours per day for distalization of the maxillary first molar, so that Class I molar relation and adequate space for correction of the upper incisor protrusion without extraction could be achieved. The fixed appliance edgewise technique was prescribed in the second stage to obtain Class I molar and canine relationships with acceptable overbite and overjet.

Group 2 : 32 patients (16 boys, 16 girls) mean aged 11.7 years, treated by fixed appliance edgewise technique with extraction of the four first premolars. Each patient was in the permanent dentition stage and cephalometric analysis indicated severe protrusion of the upper and lower incisors with mild skeletal malocclusion, indicating mainly a dentoalveolar problem.

Group 3 : 32 patients (16 boys, 16 girls) mean aged 12.5 years, treated by fixed appliance edgewise technique, non-extraction with Class II traction. Each patient was in the permanent dentition stage with fully erupted maxillary second molars, notable upper arch constriction and a narrow inter-canine width that inhibited forward movement of the mandible. Each patient had minor to moderate crowding that could be corrected simultaneously with arch expansion and levelling. The fixed appliance edgewise technique was used for upper arch expansion and a class II traction force of 4.5 - 6.5 ounces per side was applied for full time traction after obtaining arch compatibility.

At the end of treatment, all patients had Class I molar and canine relationships with an overjet of 2-3 mm and an overbite that did not exceed one-third of the lower incisor crown height. (Proffit et al., 2007)

There was no untreated control group due to ethical considerations of not treating patients with a malocclusion. The study was approved by the ethics committee of faculty of dentistry, Chulalongkorn university.

Measurements

Both T1 and T2 films were traced by the same author (WS) on acetate paper and the reference points representing hard tissue structures located (Fig. 1). Angular and linear measurements utilized for evaluation of skeletal and dental morphology before and after treatments (Fig. 2). Changes of hard tissue and soft tissue points were evaluated by means of the X-Y coordinate system. The X-axis was the SN-7° line and the Y-axis was constructed through sella perpendicular to the X-axis. The X-axis and Y-axis of the T1 film were transfered to the T2 film by structural superimposition on the stable structures (Björk and Skieller, 1983) of the anterior cranial base of the T1 film (Fig. 3). The skeletal, dental, and soft tissue morphology before treatment were evaluated from the T1 film by means of linear and angular measurements. For dental measurements, the functional occlusal plane of the pretreatment radiograph served as the X axis and the perpendicular line at the mesiobuccal cusp of first molar served as the Y axis (Figs.4, 5). Posttreatment radiographs (T2) were superimposed on the stable structures (Björk and Skieller, 1983) of the pretreatment radiographs. All landmark and measurement definitions are shown in Table 1.

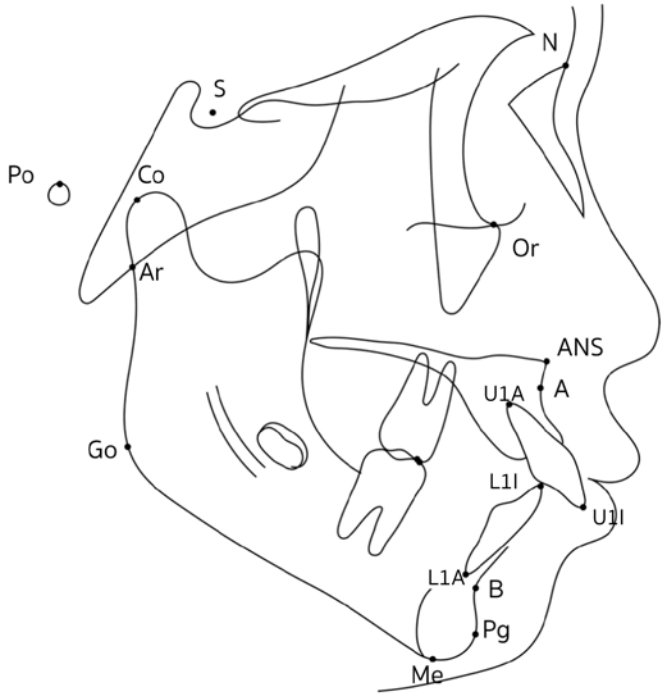

Figure 1 Cephalometric landmarks

Table 1 Definitions of landmarks and measurements

Landmark and Measurement	Definition
S	Sella, the center of sella turcica.
N	Nasion, the junction of the nasal and frontal bones.
Po	Porion, the highest point on the superior surface of the soft tissue of the external auditory meati.
Or	Orbitale, the most inferior point on the lower border of the left orbit.
ANS	Anterior nasal spine, the tip of the median, sharp bony process of the maxilla.
A	Point A, Point most posterior on the premaxilla above prosthion and immediately lateral to the
B	Point B, Point most posterior to a line from the infradentale to pogonion on the anterior surface of
Pog	Pogonion, Most anterior point on the contour of the chin, determined by a perpendicular tangent to
Gn	Gnathion, Point on the contour of the mandible determined by bisecting the angle formed by the
Me	Menton, Intersection point of the posterior symphyseal contour and the inferior contour of the
Go	Gonion, Point on the contour of the mandible determined by bisecting the angle formed by the
Co	Condylion, the most posterior superior point on the condyle of the mandible.
U1I	Upper central incisor edge
U1A	Upper central incisor apex
L1I	Lower central incisor edge
L1A	Lower central incisor apex
SNA°	Angle constructed from the two rays SN and NA.
SNB°	Angle constructed from the two rays SN and NB.
ANB°	Angle constructed from the two rays NA and NB.
SN-GoGn°	Angle constructed from the two rays SN and GoGN.
U1-NA°	Angle constructed from the two rays U1 and NA.
U1-NA linear	Distance from upper central incisor edge perpendicular to NA line.
L1-NB°	Angle constructed from the two rays U1 and NB.
L1-NB linear	Distance from upper central incisor edge perpendicular to NB line.
UFH	Upper facial height, distance from N to ANS.
LFH	Lower facial height, distance from ANS to Me.
Go-Gn	Distance from Go to Gn.

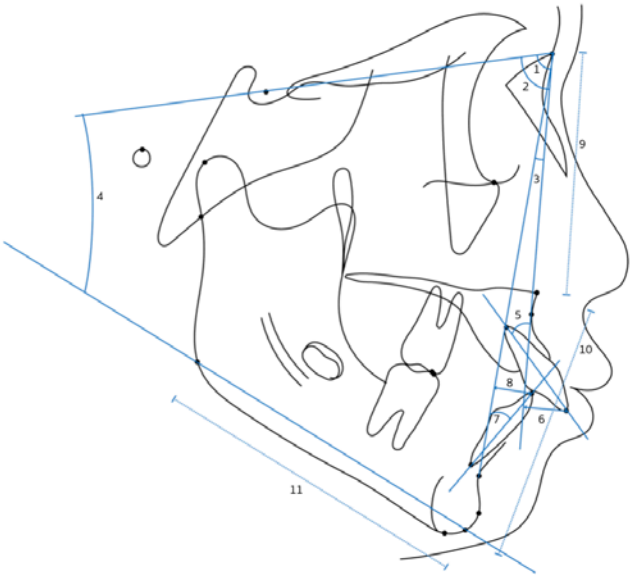

Figure 2 Angular and linear measurements

1 SNA angle, 2 SNB angle, 3 ANB angle, 4 SN-GoGn angle, 5 U1-NA (angle),

6 U1-NA (linear), 7 L1-NB (angle), 8 L1-NB (linear), 9 UFH (Na-ANS), 10 LFH (ANS-Me),

11 Go-Gn

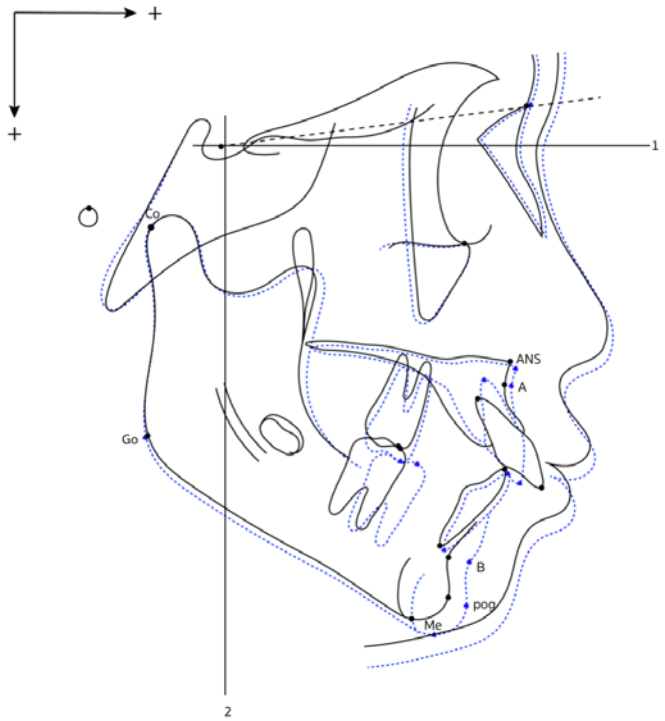

Figure 3 Cranial base superimposition reference points and planes

Line 1: x-axis, SN-7° line of T1

LIne 2: y-axis, SN-7° perpendicular line of T1

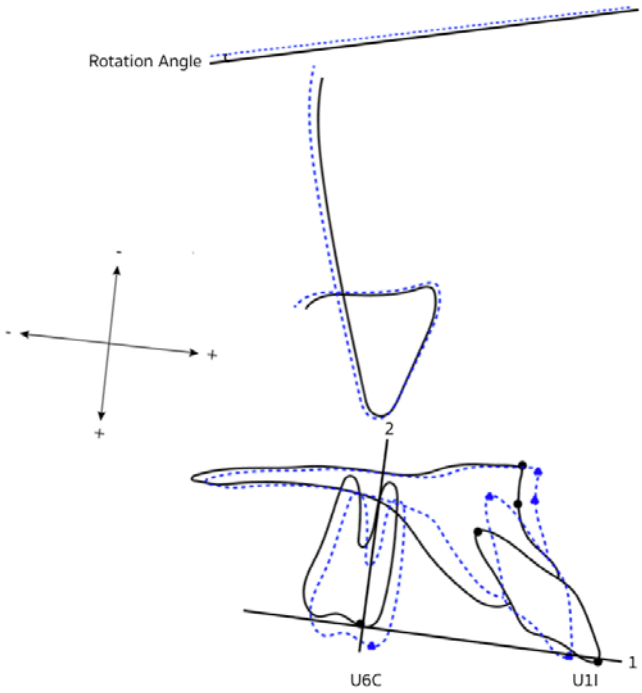

Figure 4 Maxillary superimposition reference points, planes and rotation angle

Line 1: x-axis, occlusal plane of T1

LIne 2: y-axis, perpendicular line at mesiobuccal cusp of upper first molar of T1

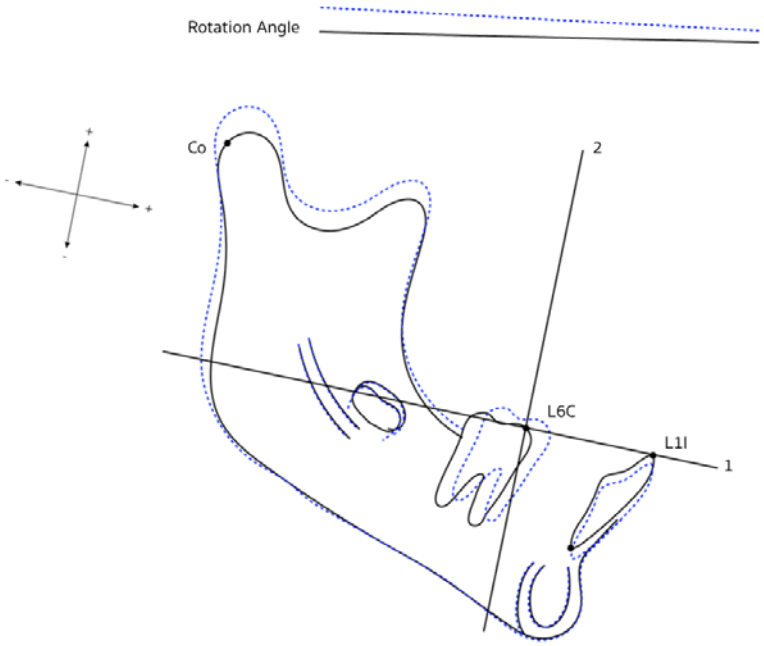

Figure 5 Mandibular superimposition reference points and planes and rotation angle

Line 1: x-axis, occlusal plane of T1

LIne 2: y-axis, perpendicular line at mesiobuccal cusp of lower first molar of T1

Statistical analysis

All data were analyzed with SPSS statistic software (version 22; IBM, Armonk, NY). Paired t-tests were used to compare the pre-treatment and post-treatment measurements. One-way ANOVA was used to analyze the differences among group means. Scheffé tests were performed for post-hoc analysis of group differences. $P<0.05$ was considered statistically significant. Because the Kolmogorov-Smirnov normality test results indicated that the raw data for a few variables were not distributed on a normal curve, Wilcoxon signed ranks and Kruskal Walis H tests were also run for those variables. Pearson's correlation coefficients were calculated between the changes derived by x-y coordinate superimposition and conventional method.

Results

Skeletal structures

Changes in skeletal structures after treatment assessed by means of linear and angular measurements are presented in Table 2. Comparing pre and post treatment, there was a significant decrease of SNA angles in all three groups along with an increase in SNB angles in Headgear group (HG group) and Class II traction group (II traction group), but SNB angles decreased only in extraction group (Ext group). However, the changes of SNA, SNB and ANB angles were not significantly different among the 3 treatment groups. On the other hand, skeletal measurements from x-y coordinates showed that the chin position in the x axis of HG group had a different significant effect. Pogonion, menton and B points of HG group were significantly different in the most forward position compared to Ext and II traction group.

In the vertical direction, SN-GoGn from conventional method were not significantly different among three groups but the result from x-y coordinate method were not the same. The intergroup differences were B and menton points, in which HG group were more downward than in II traction group.

Dental structures

The position of upper incisor were significantly different between pre- and post-treatment in every group when measured by conventional method but only HG and Ext group had differences when measured in the horizontal axis by x-y coordinate method. The position of lower incisor were different between pre- and post-treatment in Ext and II traction group when measured by both methods.

The upper and lower incisors were more retracted in Ext group than in the other groups in conventional method, as same as by x-y coordinate method in horizontal axis. Ext group had the greatest amount of anterior teeth retraction in the x axis. The inclination and position of the lower incisors in II traction group were significantly the most proclined and protruded among the three groups which can only be measured in conventional method.

Correlation

The Pearson's correlation (Table 3) showed that SNB angle was highly correlate with the changing in x axis of B, Me and Pog point, however there was not correlate with the changing in y axis of those points.

Table 2 Changes of skeletal and dental structures in each group (T2-T1)

Structure	Method		1) Headgear group		2) Extraction group		3) Class II traction group		Group differences	
			mean	sd	mean	sd	mean	sd	P value	Post hoc
Skeletal	Conventional	SNA	-1.17 *	1.69	-1.02 *	1.67	-0.70 *	1.58	0.662	ns
	(degrees)	SNB	0.19 *	1.70	-0.14 *	1.32	0.16 *	1.92	0.407	ns
		ANB	-1.58 **	1.19	-0.88 **	1.68	-0.80 *	1.53	0.063	ns
		SN-GoGn	-0.49	5.28	0.78 *	2.14	1.31 **	2.22	0.302	ns
	x-y coordination (horizontal axis, mm)	A	1.44 *	1.53	0.95 **	1.62	0.92 *	2.27	0.253	ns
		B	2.97 *	2.22	1.05	2.92	0.91	2.92	0.005 ††	1-2, 1-3
		Pog	3.73 *	2.42	1.63 *	3.06	1.02	3.40	0.001 †	1-2, 1-3
		Me	3.39 *	2.73	1.31 *	3.29	1.17	3.80	0.013 †	1-2, 1-3
	x-y coordination (vertical axis, mm)	A	-3.36 *	2.52	-2.48 *	1.85	-2.42 *	2.23	0.147	ns
		B	-7.72 *	3.75	-5.70 **	6.61	-5.30 **	3.81	0.021 ††	1-3
		Pog	-7.98 *	3.91	-6.95 *	2.91	-5.89 *	3.87	0.072	ns
		Me	-8.47 **	4.15	-7.36 *	3.00	-6.17 *	4.27	0.042 ††	1-3
Dental	Conventional	U1-NA (mm)	-1.80 *	2.26	-5.20 *	1.89	-1.52 *	2.40	<.000 †	1-2, 2-3
		L1-NB (mm)	0.72	1.91	-3.19 *	2.10	2.19 **	2.27	<.000 †	1-2, 1-3, 2-3
		U1-NA (degree)	-7.25 *	5.25	-15.4	9.18	-5.70 *	7.28	<.000 ††	1-2, 2-3
		L1-NB (degree)	2.53	6.57	-8.56	6.12	8.38	9.11	<.000 †	1-2, 1-3, 2-3
	x-y coordination (horizontal axis)	U1I (mm)	-1.22 *	2.43	-4.75 *	1.78	-0.84	3.16	<.000 †	1-2, 2-3
		L1I (mm)	0.55	2.18	-3.45 **	3.38	2.41 *	2.26	<.000 †	1-2, 1-3, 2-3
	x-y coordination (vertical axis)	U1I (mm)	-2.08 *	2.38	-3.27 *	2.18	-2.66 *	2.24	0.117	ns
		L1I (mm)	1.16 **	1.46	1.78 **	1.34	0.95	4.24	0.012 ††	2-3

*Significant difference (p<0.05, paired t-test)

**Significant difference (p<0.05, Wilcoxon Signed Ranks Test)

†Significant difference (p<0.05, ANOVA)

††Significant difference (p<0.05, Kruskal Wallis H test)

ns, No significant group differences at .05 level.

Table 3 Pearson's correlation coefficients between the changes derived by x-y coordinate superimposition (B, Me, Pog) and conventional method (SNB)

	Horizontal			Vertical		
	B point	Me point	Pog point	B point	Me point	Pog point
SNB	0.473	0.420	0.435	-0.053	-0.0170	-0.161
P value	<.000	<.000	<.000	0.610	0.097	0.118

Discussion

The treatment modalities were chosen to treat Class II division 1 patients base on the development of dentition and jaw discrepancy. The HG group was treated by headgear to improve protrusive maxilla and retrusive mandible in the younger age for benefit of growth modification. In extraction group, there was more protrusive of upper and lower incisor than those of the other group. The Class II traction group, the oldest group, was hard to modify growth by orthopedic appliance.

The most used sagittal parameters in cephalometric analysis are SNA, SNB and ANB angle, (Baik and Ververidou, 2004) but the SN plane which change by growth can effect these angles due to vertical movement of nasion. (Chang, 1987) The anterior cranial base (SN) lengthens until the end of normal growth via bone apposition at the nasion which influence the value of those angles. (von Dorsche, Fanghänel et al., 1999) All those angles affected by various factors, such as the patient age, growth rotation of the jaws, vertical growth and the length of the cranial base, which can often be misleading. (Jacobson, 1975)

The results of this study showed that the angle measurement can represent the changing in horizontal direction in the same trend of x-y coordinate superimposition method presented, but only the superimposition method showed the significance of different chin point in HG group. Also these angles cannot interpret the changing in vertical direction, the suitable method was the superimposition in the y axis that can show the different value among groups. The cephalometric superimposition helps us to understand the linear and angular measurements by providing more accurate evaluation of structural displacement. The SNA value decreased in every groups but point A in superimposition method moved in anterior and downward direction. The forward growth of nasion can explain the reduction in SNA angle. Even though, the result of this study was statistically different, it may not clearly different in clinic because of small amount of value in each parameters.

For Class II discrepancy, the chin projection is important for the patient in esthetic perception. The suitable method of measurement which can detect the changing of the chin point could be used to compare the result of each modalities. The advantage of superimposition method was the clear value of patient's growth in the distance which the orthodontist can estimate this value in the horizontal

and vertical direction clinically. On the other hand the angle and linear measurement method is easy to evaluate without tracing all of the cephalometric landmark.

Conclusion

The different methods of cephalometric analysis affect the results of measurement. The anterior movement of mandible was known only by the x-y coordinate method which was important in Class II treatment hence, the x-y coordinate superimposition can be a tool to assess the different changing in each modalities.

Acknowledgement

Thank you to Kevin A. Tompkins, for editing and advice on english expression in this document.

References

Baik CY, Ververidou M. A new approach of assessing sagittal discrepancies: the Beta angle. Am J Orthod Dentofacial Orthop 2004; 126(1):100-5.

Björk A, Skieller V. Normal and abnormal growth of the mandible. A synthesis of longitudinal cephalometric implant studies over a period of 25 years. Eur J Orthod 1983; 5(1): 1-46.

Broadbent BH. A new X-ray technique and its application to orthodontia: the introduction of cephalometric radiography. Angle Orthod 1981; 51(2): 93-114.

Chang H-P. Assessment of anteroposterior jaw relationship. Am J Orthod Dentofacial Orthop 1987; 92(2): 117-22.

Hussels W, Nanda RS. Analysis of factors affecting angle ANB. Am J Orthod 1984; 85(5): 411-23.

Jacobson A. The “Wits” appraisal of jaw disharmony. Am J Orthod 1975; 67(2): 125-38.

Proffit WR, Fields H, Sarver D. Contemporary orthodontics. St. Louis: Mosby; 2007.

von Dorsche SH, Fanghänel J, Kubein-Meesenburg D, Nägerl H, Hanschke M. Interpretation of the vertical and longitudinal growth of the human skull. Ann Anat 1999; 181(1): 99-103.