Original Article

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Influence of Angle's classification and condylotrack distance on sagittal condylar inclination in a group of Thais

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Objectives: The objectives of this study were to investigate the sagittal condylar inclination (SCI) in a Thai ethnic group and to evaluate the influence of Angle's classifications, sides and condylotrack distance on the SCI.

Materials and Methods: Seventy Thai participants, ages ranging between 20-42 years old, were allocated into 2 groups according to Angle's classification, i.e., Class I (35 persons) and Class II (35 persons). The mandibular movements from a minimum to the maximum opening and excursion of the mouth were recorded using the computerized axiograph. Three SCI values at 1, 2 and 3 mm of protrusive condylar path from the hinge axis (condylotrack distance) were obtained from the graphic record of the mandibular movement. The statistical analysis of SCI according to the Angle's classification was performed using the independent samples t-test at α=.05. The difference between right and left sides were analyzed using a dependent samples t-test. The statistical analysis for the condylotrack distance was performed by a repeated measured ANOVA at α=.05.

Results: The mean SCI of 70 Thai people was 44.7±8.8 degrees independent of any factors. There was no statistically significant difference between the SCI values obtained from Angle's classification I and II. Furthermore, no statistically significant differences were observed for the left and right sides. For a condylotrack distance parameter, the mean SCI at 1 mm, 2 mm and 3 mm were 45.7±10.6, 44.8±8.6 and 43.7±7.9 degrees respectively. The SCI at 3 mm condylotrack distance were significantly lower than those of 1 mm and 2 mm condylotrack distance.

Conclusions: SCI values were statistically different related to the condylotrack distance. There was no significant difference in SCI between Angle's classification I and II group and between left and right side.

Key words: Angle's classification, Axiograph, Condylotrack distance, Ethnic, Sagittal condylar inclination, Side

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Introduction

In restorative and prosthodontic dentistry, dentists desire to transfer mandibular movements of the patient to an articulator, which allows the fabricated prostheses to move in harmony with the patient's mandibular movements. The five factors for create a balanced articulation are called Hanau's quint, they are condylar guidance, incisal guidance, occlusal plane, compensating curves and cusp height. All these factors except the condylar guidance could be modified in prosthetic dentistry. [1] If the condylar angle setting in the articulator is steeper than the condylar inclination of the patient, it may cause posterior occlusal interferences and the balanced occlusion cannot be achieved. In contrast, setting condylar inclination too low leads to a flat occlusal table that impairs the patient's esthetics and functions. [2] In case of using average condylar angle for setting the articulator, improper condylar inclination

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setting causes an increased chair-time to correct the occlusion and may contribute to the interference of restorations especially in complicated cases similar to full mouth rehabilitation.

Condylar guidance is a mandibular guidance generated by the condyle and articular disc traversing the contour of the articular eminence. [3] Sagittal condylar inclination (SCI) is the angle formed by the path of the moving condyles within the sagittal plane compared with the horizontal plane (antero-posterior movement). [3] Within the same person, the range of condylar inclination results from the shape of articular eminence of the temporomandibular joint (TMJ), the activity of the muscles which insert to the mandible, the attaching ligaments that limit of movement and the method used to register a condylar inclination. [4] The SCI is also varying from person to person depending upon many factors, including the position of condylar head, the thickness of the disc and lining tissue at the articular eminence. [5]

Craniofacial and mandibular anatomy are different between racial groups because variations in directly cranial measurements. [6-8] Caucasoid characterized by a tall dolichocephalic skull and a medium mandible. Negroid characterized by a short dolichocephalic skull, a gracile mandible and oblique gonial angle. Mongoloid characterized by a medium brachycephalic skull and a robust mandible. [6, 7] Ishwarkumar et al., [8] in 2016 studied morphometry of the mandibular condyle that displayed a statistically significant relationship with race. Hinton R J., [9] in 1983 reported that the mandibular joint size could be correlated to the overall size of the cranium and face and differ among human groups.The cephalometric analysis of many studies reported the differences between racial groups. [6, 10-12] As the result of a more flattened upper face in Mongoloid races, orbitale also assumes a more posterior position than in Caucasians, resulting in an increase of the angle between Frankfort horizontal plane to Camper's plane. [11] The significant variations between the Frankfort horizontal plane to occlusal plane angle and SCIs found in Caucasian and mongoloid groups. [13]

The articular eminence and mandibular fossa growth begins during the development of primary teeth and ceases at the age around 20 years old. [5] The condyle usually shows some degenerative morphologic change after 50 years of age. [5, 14, 15] The change in condylar inclination is a result from the morphologic change TMJ, such as remodeling in relation to the physiologic and pathologic changes in dentition. [16] The jaw relation and dental anatomy may affect the condylar inclination. Heiser et al., [17] in 2004 measured condylar inclination in orthodontic patients using a mechanical axiograph and they reported a similar increase in a condylar inclination after orthodontic treatment for both extraction and non-extraction group. Ozkan H. and Kucukkeles N., [18] in 2003 reported no difference in sagittal condylar angle between before and after orthodontic treatment for both extraction group and non-extraction group.

Many simple average value articulators or semi-adjustable articulators are designed to set an average SCI value of 30^{o}. However, the use of average SCI value will have a considerable impact on the efficacy of any articulator which may be used to mimic a patient's jaw movements. This is particularly true if the articulator is constructed from measurements gathered from a Caucasian population. [13] The ethnic variation may be a rational factor that causes differentiation in SCI values resulted from their anatomical differences. [13] However, there were only a few studies investigated the condylar inclination in Asian population. [13, 19]

The computerizd axiograph is designed to practically record the opening, closing and border jaw movements. The machine can calculate the sagittal and horizontal condylar inclination for programming the articulator. This instrument provides sufficient reliability and correlation between the axiographical recorded angle of the condylar protrusive path to the anatomic angle of the articular eminence. [20-22] The objectives of this study were to investigate the sagittal condylar inclination in a group of Thai people and to evaluate the influence of Angle's classifications, sides and condylotrack distance on the SCI.

Materials and Methods

The ethical approval for this clinical study was obtained from the Committee on the Ethics of Research on Human Beings of Mahidol University, Bangkok, Thailand (certificate of approval number MU-DT/PY-IRB 2016/048.2309). Seventy Thai ethnic volunteers were recruited in this study. The inclusion criteria for this study were 1) the age ranging between 20-50 years old, 2) no history of trauma of head and neck, 3) present of stable and definitive maximum inter-cuspation position as least 24 teeth, 4) present of permanent first molars and permanent canines and 5) no previous or present orthodontic treatment. Subjects were allocated into 2 groups according to Angle's classification, i.e., Class I 35 persons and Class II 35 persons. Each participant received information of the study and the informed consent was signed before enrolling into the study. The clinical and dental examination were performed including medical history, current medication, history of head and neck injury, history of orthodontics treatment, TMJ and muscle of mastication, dental and occlusal examination, dental midline, overjet and overbite, Angle's classification, occlusal scheme and periodontal examination according to the examination recording form. The maxillary and mandibular impression were taken using an alginate impression material (Kromopan, DMG, Firenze, Italy) and study models were fabricated using Type III dental stone (Planet, Boral Prestia, Chonburi, Thailand). The Angle's classification was categorized by the anteroposterior relationship of the first molar teeth. Angle Class I indicated by mesio-buccal cusp of upper first molar occluded to a buccal groove of the lower first molar. Whereas the mandibular first molar is distal to the maxillary first molar was classified as Angle Class II. [3]

Mandibular movements and SCI values were recorded and analyzed using the computerized axiograph (Sam Axioquick recorder II version 1.0, SAM Prazionstechnik, Munich, Germany). The components of a computerized axiograph were presented in Figure 1(a). The lower clutch system was made from a para-occlusal clutch that attached to a labial surface of the lower anterior teeth using the individual impression index made from a bisacryl material (Luxatemp HM, DMG GmbH, Hamburg, Germany) as shown in Figure 2. The upper flag bow was positioned by seating the porion earpieces inward to the ear. The interpupillary leveler was settled to align with the eye pupils and the nasion relator. Then the vertical head support, mastoid bone support and secondary support were secured in place. The lower flag bow was attached to the lower clutch system. The earpiece alignment protocol places the horizontal axis orbital reference plane identical to the Frankfort horizontal plane as shown in Figure 1(b).

Before the jaw movement record, each participant was seated comfortably in a head upright position. The recording sequences started with opening and closing the mouth within 10 mm to determine hinge axis. Afterwards maximum opening-closing, protrusive-retrusive movements and right-left lateral eccentric movements were recorded respectively. Participants were asked to repeat all of the movements for three times without any guidance. The axiogram output consisted of the graphic records in protrusion, laterotrusion, mediotrusive, translation and rotation. The SCI values were determined relative to the distance in mm of protrusive condylar path from hinge axis (condylotrack distance). Three SCI values at 1, 2 and 3 mm condylotrack distance for both right and left condyles were analyzed.

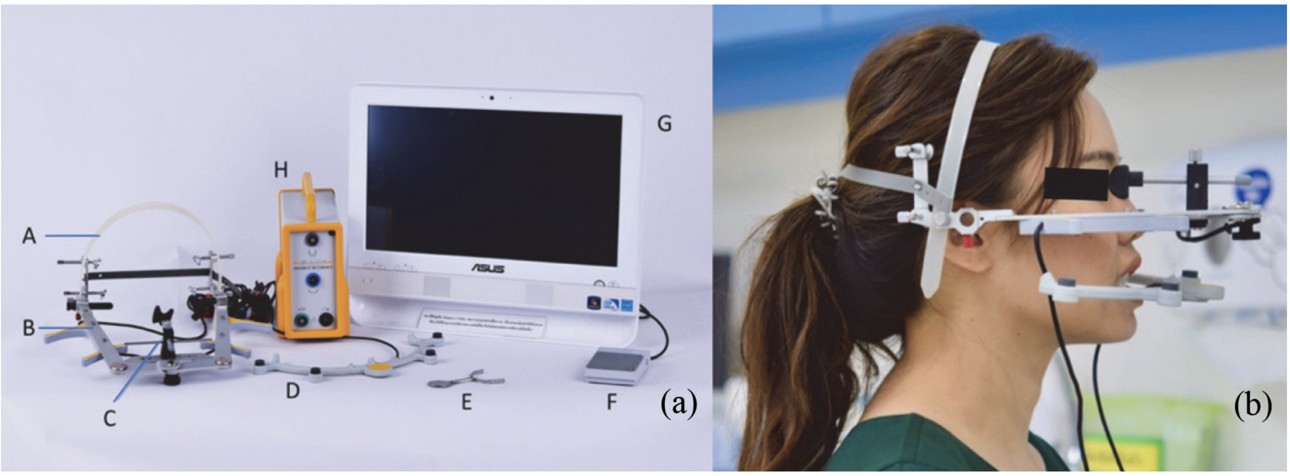

Figure 1 (a) The axioquick recorder apparatus. A: vertical support band, B: upper flag bow with ultrasonic receivers, C: nasion relator, D: lower flag bow with ultrasonic transmitters, E: para-occlusal clutch, F: foot control, G: PC software, H: power supply, (b) The upper and lower flag bow were positioned.

Figure 2 The para-occlusal clutch with impression index

The statistical analyses of the recorded data were carried out using SPSS statistical software (SPSS 18.0, SPSS Inc., Chicago, IL, USA). According to the Angle's classification, the normal distribution of data was examined using the Shapiro-Wilk test. Levene's test for equality of variances was also performed. The statistical analyses of SCI for the Angle's classification was performed using an independent samples t-test at α=.05. The difference between right and left SCI was analyzed using a dependent samples t-test at α=.05. The condylotrack distance factor was statistically evaluated by a repeated measured one-way ANOVA followed by a paired t-test.

Results

Seventy Thai participants comprised of 17 males and 53 females. Their age ranged from 20 to 42 years old. The mean age was 27±5.6 years old (Class I 28.7±5.6 years old, Class II 25.4±5.2 years old). The SCI values of all participants were 29.0 - 69.5 degrees with the average SCI of 44.7±8.8 degrees.

The mean SCI of Angle Class I was 43.7±8.5 degrees. The mean SCI of Angle Class II was 45.8±9.1 degrees. The means, ranges and standard deviations of the SCI values according to Angle's classification are presented in Table 1. The results obtained from the Shapiro-Wilk test showed that the data were normally distributed. There were no statistically significant differences between the SCI of Class I and Class II (P=0.327). In addition, Class II were divided to Class II division 1 that was characterized by narrowing of the upper arch and protruded maxillary incisors and Class II division 2 that was characterized by less narrowing of the upper arch and lingually inclined of the maxillary incisor. [3] The mean SCI of Class II division 1 was 45.2±9.2 degrees (in the range of 29.7 - 69.5 degrees). The mean SCI of Class II division 2 was 48.1±8.2 degrees (in the range of 37.2 - 59.9 degrees).

The means, ranges and standard deviations of the SCI values according to right and left sides are presented in Table 2. The result from the dependent t-test revealed that there were no significant differences between the SCI obtained from the right and left sides (P=0.486). The linear trend line showed a weak relationship between the right and left sides (R^2 = 0.445) as shown in Figure 3. The mean difference of SCI on both sides of each participant was 6.4±4.5 (in the range of 0.5 - 24.1 degrees). 45.7% of the participants exhibited the higher SCI values on the right condyle than that on the left side. On the other hand, 54.3% participants had higher SCI values on the left side. The differences in SCI value on both sides of each participant were less than 5 degrees in 40% participants, 5 - 10 degree in 44.3% participants, and more than 10 degrees in 15.7% participants.

The means and standard deviations of the SCI values according to condylotrack distance are presented in Table 3. There was no significant difference of SCI between distance 1 mm and 2 mm (P = 0.078). However, a significant difference of SCI between distance 1 mm and 3 mm and between distance 2 mm and 3 mm were reported.

Table1 Means, ranges and standard deviations of the SCI (in degrees) according to Angle's classification

Angle's classification	SCI (degrees)		
	Mean	Range	SD
Class I	43.7	29.0 - 60.2	8.5
Class II	45.8	29.7 - 69.5	9.1
total	44.7	29.0 - 69.5	8.8

Table2 Means, ranges and standard deviations of the SCI (in degrees) according to sides

Side	SCI (degrees)		
	Mean	Range	SD
Right side	45.1	23.5 - 65.0	9.9
Left side	44.4	24.7 - 73.9	9.4

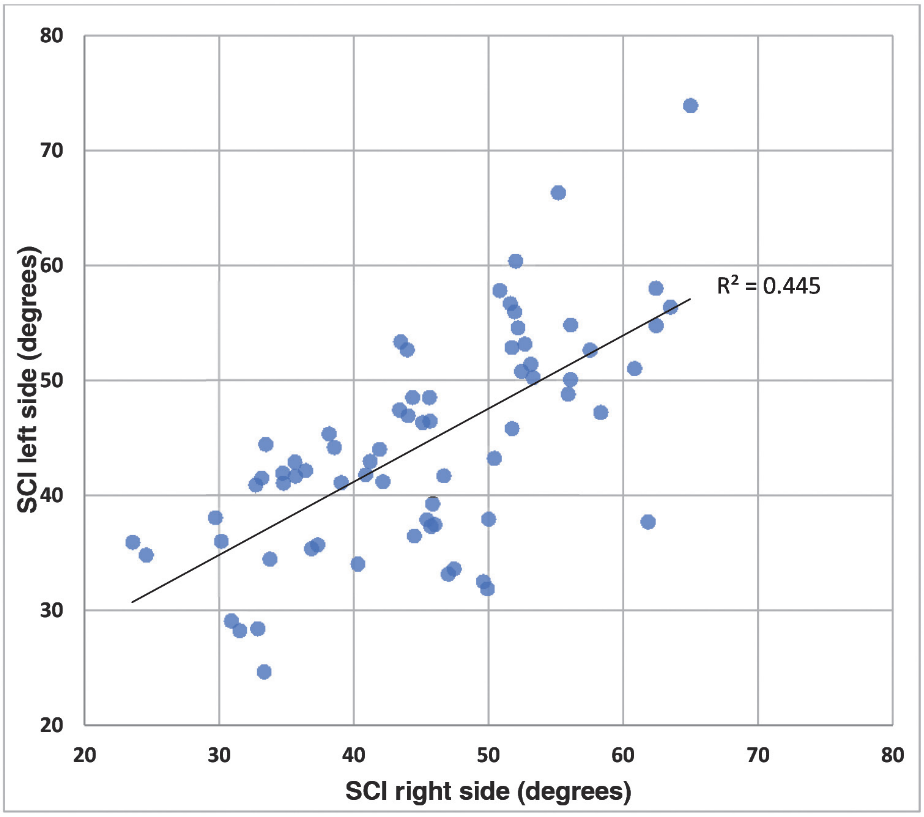

Figure 3 Right and left SCI values of all participants.

Table 3 Means, ranges and standard deviations of the SCI (in degrees) according to condylotrack distances

Condylotrack distance	SCI (degrees)		
	Mean	Range	SD
1 mm	45.6	27.1 - 74.1	10.6
2 mm	44.8	28.2 - 68.7	8.6
3 mm	43.7	28.4 - 65.5	7.9

Discussion

The correlation of Angle's classification and side difference to condylar inclination were verified in some studies. Motoyoshi et al., [23] in 1993 reported that there was no difference in SCI between Class I and Class II groups. Santos PF., [24] in 2013 revealed that Class II division 2 had steeper SCI than the other class. Stamm et al. [25] and Canning et al. [26] also reported that the SCI of Class II division 2 was steeper than Class I group. In this study, the results showed that Class II division 2 had slightly steeper SCI values than that of Class II division 1 and Class I even no statistically significant differences were observed. The maxillary anterior teeth are known to be an influencing factor on eminence inclination. [24] There were evidences that deep bite people had steeper angle of rotation of condylar head than that of normal bite. [27] Katsavrias E.G. and Halazonetis D.J. [28] investigated the positions of condylar head by the tomogram technique and they reported that the Class II division 2 group had a more posteriorly placed condyle than the Class II division 1. The steep condylar inclination leads to reduced sagittal movement, lock of occlusion and increases strain in temporal muscle which may disturb the temporomandibular joint functions. [29, 30]

For the side difference, there was no significant difference on SCI values between right and left side observed in this study. This result was corresponded with those obtained from the studies of Katsavrias EG. [5] and Reicheneder et al. [31] The study of Ichikawa and Laskin [32] showed that left and right side of the bony articular eminence did not differ significantly using the direct measurement of adult Asiatic Indian skulls. A symmetrical growth pattern of both articular eminence is a reasonable support about indifference between right and left side. [5] Jasinevicius et al., [33] studies on the skulls and reported that 90% exhibited more than 5° right-left asymmetry of the glenoid fossa. Zamacona et al [34] found the difference of SCI on both side were 6.8° and more than 10° difference on both side were shown in 21.4% participants. The study of Cimic et al. [35] showed that there was an intra-variation of SCI in left and right side and a greater difference even more than 10 degrees could be considered as a normal. In this study, the amount of participants with right SCI value more or less than left side were almost equal. More than 80% participants had different SCI less than 10 degrees between left and right sides. 11 participants which can be classified to 9 participants in Class II group and 2 participants in Class I group. The amount of participants showed more than 10 degrees of SCI difference between left and right sides.

From the previous studies using direct measurement of articular eminence, they founded that the inclinations of articular eminence were different depend on the position of eminence. [32, 33] Ichikawa and Laskin in 1989 discovered that the mean angulation of the midpoint inclined plane was significantly greater than that of the lateral inclined plane. [32] Jasinevicius et al. [33] considered that the central angle of eminence was consistently steeper than the medial angle, and the lateral was generally steeper than the medial. However, the temporomandibular joint is not only bony structures, but also including of articular disc and neuromuscular system. The condylotrack distances in the range of 1-3 mm in excursive movement refer to a movement in a central part of an articular eminence that is the exact SCI measurement. [31]

From the present study, the SCI at distance 1 mm and 2 mm were steeper than that of the distance 3 mm. The different SCI values depends on a distance of recording because the true condylar paths are invariably curved. Most semi-adjustable articulators provide only straight lines of condylar path. Static positional records have been recommended using eccentric interocclusal records for setting the SCI of a semi-adjustable articulator. The eccentric interocclusal record can measure only one position of the condylotrack distance. Therefore, a straight condylar path of semi-adjustable articulator is accurate only at the position where the record is made. [36] From the result of this study, the condylar inclination position close to centric occlusion is steeper. If the articulator setting cannot make the accurate condylar path angle, it is better to set the least angle or lower inclination along the border movement to avoid occlusal interferences after fabricating the restoration. According to the results obtained in this study, the SCI value at 3 mm of condylotrack distance might be clinically applicable to be used as the static position of eccentric interocclusal record, because this was the distance that had the significant less values. However, the difference between the distance of condylar path and the protrusive length of the jaw (anterior movement of the jaw or teeth) should be recognized that they are not the same distance. [25]

Most of the preceding SCI studies using axiographic technique were performed in Europe but the ethnic group was not identified. The mean SCI values in those studies were reported to be approximately 41.9-61 degrees. [25, 26, 29, 35, 37-39] Only a few SCI studies identified the ethnic group nevertheless using the difference SCI measuring technique. [19, 33, 40] Cohlmia et al., [40] in 1996, reported the mean SCI of Caucasian adults which were 49.1-59.0 degrees using the tomography. Jasinevicius et al., [33] in 2005 studied from dry skulls of African-Americans and European-Americans reported the mean SCI was 54.4 degrees. Wu et al., [19] in 2012 reported the mean SCI in Taiwanese which was 39.3 degrees using the computerized tomography. From the previous studies, there were the high variability in the reported SCI values. This variation could result from the variation in the ethnic group of subjects and the SCI measuring technique. In this study, the average SCI of Thai ethnic group was 44.7 degrees. The mean SCI value in this study consistent to the preceding studies. [26, 37] However, Fletcher AM. founded a tendency that Asian population had lower SCI values than the Caucasian because of the tight orofacial musculature and basic anatomy of maxilla and temporomandibular joint. [13] In case of using average condylar angle for setting the articulator, the use of the general average SCI value of 30^{o} would be practical to avoid occlusal interferences of the restoration for Thai ethnicity according to the result of SCI values obtained in a group of Thais in this study.

Condylar inclination affects the cuspal inclination of the teeth in both protrusive and nonworking movements. A steep condylar inclination allows steeper inclines on the cusps of the teeth, while a less steep inclination demands a flatter occlusal surface with shallower cuspal inclination. [41, 42] Price et al., [42] in 1991 revealed that 5° change in condylar inclination setting caused a 0.24 mm change in the nonworking cusp height at a 3 mm laterotrusion movement of first molar. However, the nonworking ridge and groove positions were less affected than the cusp height. In case of the balanced occlusion, the occlusal surfaces of posterior teeth simultaneously contact the opposing teeth in excursive movement. Because of the curved condylar path, one angle value of the cuspal inclination cannot make a perfectly continuous guidance which provide an uninterrupted gliding movement in all border movement along condylotrack distances. From the results obtained in this study, it is advisable that the cuspal inclination for restorations at the position distant from the centric occlusion should be less steep than those which are close to centric occlusion in order to make a perfectly protrusive and nonworking contact.

Conclusion

The average SCI values in a group of Thai people in this study was 44.7±8.8 degrees. SCI values were statistically different related to the condylotrack distance. There was no significant difference in SCI between Angle's classification I and II group and between left and right side.

Funding : None

Conflicts of Interest : None

Ethical approval : The ethical approval for this clinical study was obtained from the Committee on the Ethics of Research on Human Beings of Mahidol University, Bangkok, Thailand (certificate of approval number MU-DT/PY-IRB 2016/048.2309)

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