CHAPTER II

LITERATURE REVIEW

Andrews (1972) determined crown inclination from the impression models of 120 non-orthodontic patients with normal occlusion. The inclination was expressed in plus or minus degree, representing the angle formed by a line perpendicular to the occlusal plane and another line (LACC) tangent to the midpoint of the labial or buccal long axis of the clinical crown (LA point). As viewed from the mesial or distal, the tangent line would separate the occlusal and gingival portions of the crown at the midpoint of the clinical crown (Figure 1). A plus reading was given if the gingival portion of the crown was lingual to the incisal portion. A minus reading was given if the gingival portion of the crown was labial to the incisal portion. He found that the upper anterior crown inclination was positive while the lower anterior crown inclination was slightly negative. An almost constant negative crown inclination existed in the upper posterior teeth. A progressively greater minus crown inclination existed from the lower canines through the lower second molars. He described the torque values in Table 1.

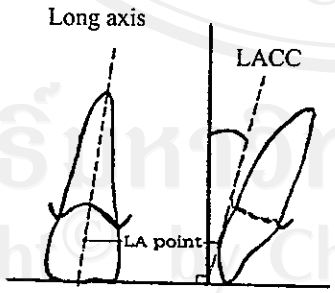

Figure 1 Crown inclination was determined by the resulting angle between a line 90 degrees to the occlusal plane and the line tangent to the middle of the labial or buccal clinical crown.

Table 1 Crown inclination described by Andrews(1976).

Tooth	Inclination (degree)	
	Upper	Lower
Central incisor	+7	-1
Lateral incisor	+3	-1
Canine	-7	-11
First premolar	-7	-17
Second premolar	-7	-22
First molar	-9	-30
Second molar	-9	-35

Dellinger (1978) studied torque value from the setup models of 25 non-extraction and 25 extraction cases. The horizontal occlusal line (HOL) was established as occlusal plane to measure inclination of a crown. This line was constructed in both maxillary and mandibular arches. The first molar and central incisor clinical crown heights were bisected after adding a 1 millimeter gingival sulcus depth. The HOL could be established by connecting left and right midcrown first molar points and the clinical crown average of the left and right central incisors (Figure 2). His study was different from Andrews' study. The crown inclination of central and lateral incisors were smaller than those of Andrews' study, but the others were greater.

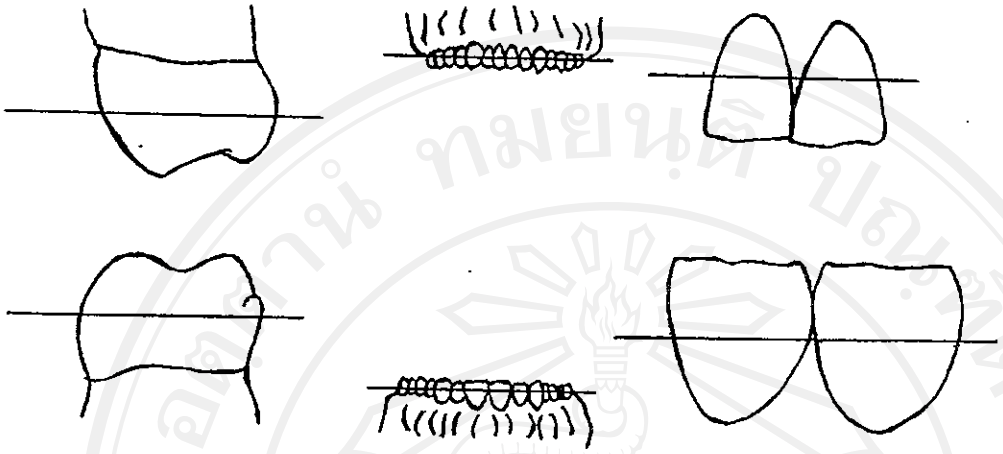

Figure 2 Horizontal occlusal lines

Vardimon and Lambertz (1986) studied the impression models of 54 ideal occlusions (34 orthodontically treated and 20 untreated cases). They evaluated the torque values and determined the predictor for individual torque from a diagnostic setup, morphometric dental parameters and the given torque values of any other teeth. Their study was in close agreement with Andrews' mean torque values except those for the upper incisors. Neither the setup procedure nor the morphometric parameters predicted individual torque data but the first premolars in each arch were the teeth of choice for predictive purposes.

In northern Thai adults with good occlusion, pertaining to Duangtaweesub's study (1997), he constructed occlusal plane as described by Dellinger's concept. The results were that the crown inclination of upper and lower anterior teeth had positive values, while those of the posterior teeth had negative values. The crown inclination of upper posterior teeth showed continuously lingual crown torque. That of the lower posterior teeth showed progressively lingual crown torque (Table 2).

Table 2 Crown inclination described by Duangtaweesub (1997).

Tooth	Inclination (degree)	
	Upper	Lower
Central incisor	+8.20	+5.36
Lateral incisor	+6.27	+2.26
Canine	-5.95	-3.77
First premolar	-8.04	-13.91
Second premolar	-8.20	-18.93
First molar	-9.50	-25.17
Second molar	-8.38	-34.69

Skeletal morphology variation is one of the factors affecting axial inclination. In cephalometric analysis, the long axis of the incisors is defined as the line passing through the point of incision superius (midpoint of the cutting edge) and the apex. Measuring the tooth inclination, the long axis of the incisor is certainly related to various skeletal cephalometric planes.

Steiner (1960) calculated what compromised incisor inclination and position to achieve normal occlusion when the ANB angle was not ideal (ANB = 0-4 degrees). In the Steiner's compromise chart, the axial inclination varies with the size of the ANB angle (Figure 3). If the ANB angle becomes higher than ideal angle, the upper incisors will be more upright, but the lower incisors will be more protrusive.

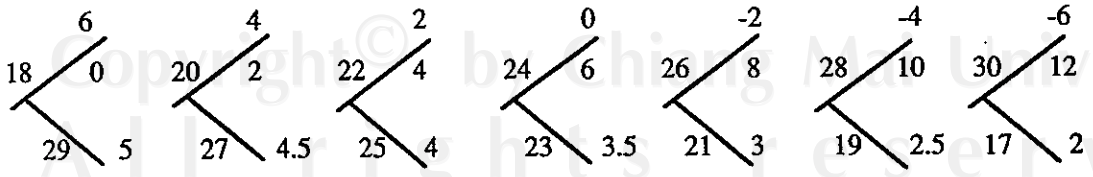

Figure 3 Steiner's acceptable compromised chart (Proffit and Fields, 1993)

Tweed (1966) found that there was correlation between the inclination of the mandibular incisors and the mandibular plane angle; the steeper the mandibular plane angle, the more effectively procumbent the mandibular incisors.

Hasund and Ulstein (1970) found that the axial inclination of the upper incisors became more protrusive in the prognathic face (SNB, SNPog) and had to be more upright in the rethognathic face related to the anterior cranial base. The basal sagittal discrepancy (ANB) showed a negative correlation with the axial inclination of the upper incisors in relation to the NA line and showed a positive correlation with the axial inclination of the lower incisors in relation to the NB line.

Bibby (1980) investigated how the incisors were accommodated and whether there was any consistent pattern. The results showed that a compensatory adjustment could be seen in the incisors. This compensation acted to reduce the anteroposterior skeletal discrepancy and to allow the normal incisor relationship. In skeletal class III type, the lower incisors would retrocline in protrusive mandible but the upper incisors would procline to meet them (Figure 4). For skeletal class II type, the upper incisors would retrocline in protrusive upper jaw, whereas the lower incisors were similarly or slightly more proclined than those in class I (Figure 5).

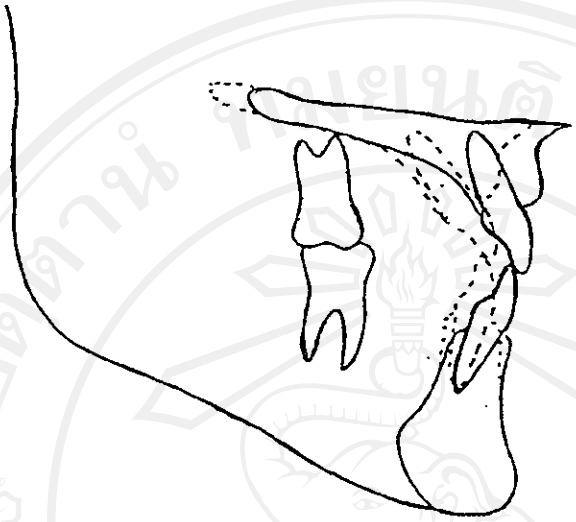

Figure 4 Incisor compensation in skeletal class III (Bibby, 1980)

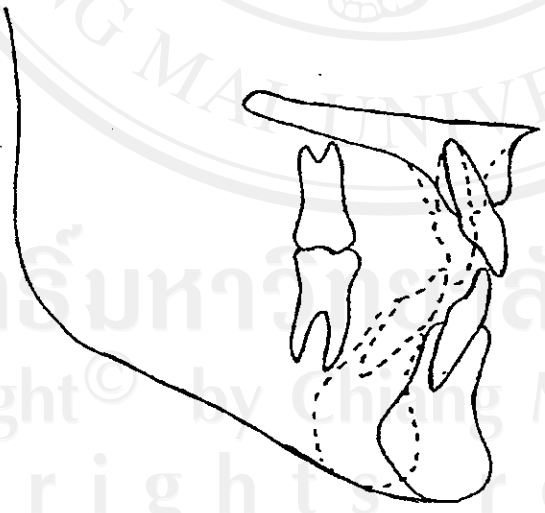

Figure 5 Incisor compensation in skeletal class II (Bibby, 1980)

Hasund and Boe (1980) investigated 74 Norwegian adults (37 males and 37 females) with ideal occlusion and harmonious soft tissue profile. They concluded that the nature was able to achieve an ideal occlusion even if many cases showed a basal configuration quite different from what was expected to be ideal (ANB angle = 0-4 degrees). It seemed as if nature in these cases used the variation in incisor position to compensate for different sagittal and vertical basal relationship. Establishment of the individualized positioning of the lower incisors was based upon three basal variables; the ANB angle, the ML-NL angle and the chin prominence (N angle). Applying the three basal variables, the following multiple regression equation was found :

$\bar{1}$-NB (mm.) = 0.47 (ANB) + 0.11 (ML-NL) + 0.06 (N-angle) - 2.40

Casko and Shepherd (1984) evaluated the correlations between various dental and skeletal parameters in 79 Caucasian adults with untreated ideal occlusion. He found that when the ANB angle, the mandibular plane angle and the occlusal plane angle increased, the maxillary incisors were more upright but the mandibular incisors were more protrusive.

Perera (1987) examined a sample of 29 untreated subjects over a period of approximately nine years. The sample consisted of serial records of lateral cephalograms and dental study casts. The mean age was 11.2 $\pm$ 1.1 years at the initial radiograph. The results indicated that as the rotational growth of mandible (NSGn) was more forward, the lower incisors would tend to retrocline.

In Norwegian and Thai adults with ideal occlusion, Jotikasthira (1988) found that the ANB angle was significantly negatively correlated with the inclination of the upper incisors and position of the incisal edge in relation to the NA line in both sexes. Moreover, the ANB angle was positively correlated with the inclination of the lower incisors and the position of lower incisal edge in relation to the NB line, but not significant in Thai males. The chin prominence was significantly positively correlated with the inclination of the lower incisors and position of the lower incisal edge in relation to the NB line in both males and females.

Ross et al. (1990) found that if the mandibular and occlusal plane angles increased the inclination of upper incisors related to the occlusal plane would increase, and that the inclination of the lower incisors related to the mandibular plane would be more upright as the mandibular plane angle increased.

In conclusion, the correlations between skeletofacial variables and crown inclination are summarized as follows.

1. The ANB angle is negatively correlated with the inclination (Steiner, 1960 ; Hasund and Ulstein, 1970 ; Bibby, 1980 ; Casko and Shepherd, 1984 ; Jotikasthira, 1988) and the position of the incisal edge of the upper incisors (Steiner, 1960 ; Jotikasthira, 1988). Moreover, it is positively correlated with the inclination (Steiner, 1960 ; Hasund and Ulstein, 1970 ; Bibby, 1980 ; Casko and Shepherd, 1984 ; Jotikasthira, 1988) and the position of the incisal edge of the lower incisors (Steiner, 1960 ; Hasund and Boe, 1980 ; Jotikasthira, 1988).

2. The SNB angle is positively correlated with the inclination of the upper incisors related to the anterior cranial base (Hasund and Ulstein, 1970).

3. The correlation between the facial depth (SNPog) and the inclination of the upper incisors is the same as the SNB angle (Hasund and Ulstein, 1970).

4. The chin prominence (N angle) is positively correlated with the inclination (Jotikasthira, 1988) and the position of the incisal edge of the lower incisors in relation to the NB line (Hasund and Boe, 1980 ; Jotikasthira, 1988).

5. The mandibular plane angle (SN-MP) is negatively correlated with the inclination of the upper incisors (Casko and Shepherd, 1984 ; Ross et al., 1990) and positively correlated with the inclination of the lower incisors (Tweed, 1966 ; Casko and Shepherd, 1984 ; Ross et al., 1990)

6. The Y growth axis angle (NSGn) is positively correlated with the inclination of the lower incisors (Perera, 1987).

7. The correlations between the occlusal plane angle (SN-OP) and the inclination of the upper and lower incisors are the same as the mandibular plane angle (Casko and Shepherd, 1984 ; Ross et al., 1990).