Evaluation of Andrews' six keys of normal occlusion in a sample of Iraqi adults in Baghdad city

Ammar Sh. Al-Ubaydi, B.D.S. [(1)]
Nagham M.J. Al- Mothaffar, B.D.S., M.Sc. [(2)]

ABSTRACT

Background: The Andrews' six keys of normal occlusion contribute individually and collectively to the total scheme of occlusion and, therefore, are viewed as essential to successful orthodontic treatment. The present research aims to evaluate the presence of the parameters of the Andrews' Six Keys of normal occlusion in a sample of 100 Iraqi adults with complete permanent dentition and clinically acceptable normal occlusion (Angle's Class I) in Baghdad city. Their age range 18-25 years (60 males and 40 females).

Materials and methods: Each patient was subjected to clinical examination and then study cast models were made, with their occlusal records. The measuring tools that have been used involved: *Three-dimensional goniometer* to measure crown angulation and inclination, *Interlandi template* to measure tooth rotation and *digital calliper* to measure curve of Spee.

Results: The results that were obtained showed that the distribution of Andrews' six key was achieved as follow: the Interarch relationship (key I) which is composed of seven items was achieved in most of models (72%); the Angulation (key II) was achieved in 67%; the Inclination (key III) was showed in less than half of the sample (41%); the Rotation (key IV) was achieved in 62%; the Interproximal contact (key V) was achieved in 57% and the Curve of Spee (key VI) was achieved in all models (100%).

Conclusion: this study found that only 10% of the models presented with all six keys simultaneously. Whereas the higher percentage (34%) was found with four keys and only one model presented with one key (1%).

Keywords: Andrews' six keys, normal occlusion. (J Bagh Coll Dentistry 2013; 25(2):130-139).

INTRODUCTION

Angle in 1899 published his book "The Classification of Malocclusions" was an important step because he was not only identify the main types of malocclusion, but also included the first clear and simple definition of normal occlusion in its natural dentition. Over time, definitions have been sought for more accurate and safer ways to identify patterns of normal occlusion[(1)].

The six keys of normal occlusion were a system of structural interdependence and that formed the basis for the assessment of orthodontic patients, and that the failure of one or more keys indicates an *inadequate* occlusion. The clinical experience and observations of treatment exhibits at national meetings and elsewhere had increasingly pointed to a corollary fact-that even with respect to the molar relationship itself, the positioning of that critical mesiobuccal cusp within that specified space could be inadequate. Too many models displaying that vital cusp-embrasure relationship had, even after orthodontic treatment, obvious inadequacies, despite the acceptable molar relationship as described by Angle[(2)].

At first, little attention was paid to the dental occlusion, and focus was laid on the tooth alignment and correction of facial proportions.

Extractions were common to tackle dental problems, for crowding or misalignments, and the details of occlusal relationships were considered unimportant. A static evaluation of occlusion that was examined in relation to Andrews' scheme and associated with centric occlusion depended on the appropriate position of each individual tooth. For him, the six keys were quite helpful, but should include functional goals [(3)].

Since antiquity the incorrect dental position has been presented as a problem for many people, and attempts to fix it date back to at least 1000 BC. Terminologically, the word "occlusion" means close up: "oc" = up, "clusion" = close. The original concept refers to an action executed, literally an anatomical approach, a description of how and when the teeth are in contact. As dentistry developed in the eighteenth and nineteenth centuries, a large number of devices for the adjustment of the teeth were described by several authors. In 1890, Edward A. Angle began to do research in the area of occlusion. Initially he had the greatest interest in prosthesis but his growing dedication to the dental occlusion and treatment necessary to have a normal occlusion led to the development of orthodontics as a specialty, and he was then regarded as the father of modern orthodontics. Although, the Six Keys to Occlusion of Andrews are now reference to the goals of treatment, most research uses the control sample of the group with normal occlusion established by the method described in 1907 by Angle, which accounts for finding such low

(1) MSc Student, Department of Orthodontics, College of Dentistry, University of Baghdad.
(2) Assistant Professor, Department of Orthodontics, College of Dentistry, University of Baghdad.

prevalence of the six keys in occlusions classified as normal[4].

Andrews examined hundreds of models seeking similar characteristics among them. He reported six significant characteristics consistently observed in 120 casts of non-orthodontics adult patients (*18-25 years old*) with normal occlusion [2], which were:

Key I: Molar relationship: The distal surface of the distobuccal cusp of the upper first permanent molar made contact and occluded with the mesial surface of the mesiobuccal cusp of the lower second molar. The mesiobuccal cusp of the upper first permanent molar fell within the groove between the mesial and middle cusps of the lower first permanent molar. The canines and premolars enjoyed a cusp-embrasure relationship buccally, and a cusp fossa relationship lingually.

Key II: Crown angulation (*the mesiodistal "tip"*): refers to angulation (or tip) of the long axis of the crown, not to angulation of the long axis of the entire tooth. The long axis of the crown for all teeth, except molars, is judged to be the middevelopmental ridge, which is the most prominent and centermost vertical portion of the labial or buccal surface of the crown. The long axis of the molar crown is identified by the dominant vertical groove on the buccal surface of the crown. Crown tip is expressed in degrees, plus or minus. The degree of crown tip is the angle between the long axis of the crown (as viewed from the labial or buccal surface) and a line bearing 90 degrees from the occlusal plane. A "plus reading" is awarded when the gingival portion of the long axis of the crown is distal to the incisal portion. A "minus reading" is assigned when the gingival portion of the long axis of the crown is mesial to the incisal portion.

Key III: Crown inclination: (labiolingual or buccolingual inclination): refers to the labiolingual or buccolingual inclination of the long axis of the crown, not to the inclination of the long axis of the entire tooth. Crown inclination is expressed in plus or minus degrees, representing the angle formed by a line which bears 90 degrees to the occlusal plane and a line that is tangent to the bracket site (which is in the middle of the labial or buccal long axis of the clinical crown, as viewed from the mesial or distal). A plus reading is given if the gingival portion of the tangent line (or of the crown) is lingual to the incisal portion. A minus reading is recorded when the gingival portion of the tangent line (or of the crown) is labial to the incisal portion.

Key IV: Rotations: The fourth key to normal occlusion is that the teeth should be free of undesirable rotations.

Key V: Spaces: The fifth key is that the contact points should be tight (no spaces).

Key VI: Occlusal plane: The planes of occlusion found on the nonorthodontic normal models ranged from flat to slight curves of Spee.

MATERIALS AND METHODS:

The sample of this study was collected from the researcher private clinic and diagnosis department, college of dentistry, University of Baghdad. Out of 250 clinically examined Iraqi adult subjects, only 100 subjects (60 male and 40 female, age range 18-25) were selected when met a special criteria, which were:

1. Full set of permanent teeth (excluding the 3rd molar).
2. Clinically skeletal class I determined by two finger method [5], and bilateral class I molar and canine relationships, with normal overjet and overbite (2-4 mm).
3. Well-aligned arches with no supernumerary teeth and no clear rotation by visual examination.
4. Normal appearing teeth, no badly carious lesion, no missing or extracted teeth.
5. No large restorations or fixed replacement.
6. No history of previous orthopaedic, orthodontic or facial trauma.
7. No gross asymmetries in the dental arches and face.

- **Examination and clinical tools:** Dental mirrors, Kidney dish, Antiseptic solution (Spirit 75%), Cotton, Sliding calliper to measure the overbite and overjet, Impression metallic trays, Alginate, Dental stone and plaster of Paris, Sheet wax, Sprit lamp, Rubber bowls and spatula.

- **Laboratory and other equipments:** Trimmer, Separating media (Vaseline™), two glass slabs (15cm × 20cm), Plastic blocks (Bricks) (1.5cm × 3cm), Micro-motor engine with round large carbide bur, two hundred transparent plates (1mm thick), marker pen and Black pencil.

- **Measurement equipments:** *Three-Dimensional Goniometer* (wooden type) which is a simple device constructed by the researcher and designed to measure Rotation, Tip and Torque (RTT) for each individual tooth (figure 1, 2 and 3), *Plane rotation control* (PRC) template or the so-called Ray set® template (figure 4), which is essential for preliminary analysis of the 1st order positions of the teeth (each line of template represents 2°) [6]**,** *Orthodontic Interlandi diagram* for tooth rotation measurement (figure 5) [7], Digital caliper with precision of up to 0.01 mm

for linear measurement and Millimetre plastic ruler.

History and clinical examination: Each individual was seated on a dental chair with his / her Frankfort head plane horizontal to the floor, to assess the skeletal Class I relationship clinically [5]. Information about his / her name, age, origin, history of facial trauma and previous orthodontic treatment was taken. Then intraoral examination was done for each person to check the criteria that should be present.

Ø **Clinical work:** With metallic trays upper and lower impressions were taken by alginate, then Dental occlusion was recorded by using double layer of wax (7mm) [8].

Ø **Laboratory work:**

1. The impression was poured using dental stone.
2. After that the dental cast was removed from impression tray, and the occlusal surface of the upper arch was placed on the glass slab.
3. Two plastic blocks (*Bricks*) were placed one over the other on each corner of the glass slab, so that the height of the bricks became 2.25 cm.
4. Plaster of thin consistency was mixed and then poured on the base of the upper cast.
5. The 2nd glass slab was painted with separating media, so that the isolated surface was placed over the plastic blocks and pushed until it touched them in 4 corners. By this way the excess of plaster material escaped from the sides of the cast, so that the base of the upper cast became parallel to the occlusal plane.
6. When the plaster became set the upper cast was removed from the glass slab and turned over so that the base of the cast was repositioned on the glass slab.
7. The plastic blocks were repositioned on the corner of the glass slab, and their height was increased by adding two other blocks on each of the previous blocks, so that the number of blocks on each corner became four and their height became 4.5 cm.
8. Now the lower cast was positioned on the upper cast using the bite registration wax which was previously taken for each subject.
9. Again the 2nd glass slab was separated with separating media, and then the plaster was mixed and poured on the base of the lower cast. After that the isolated surface of the slab was placed over the plastic blocks and pushed until it touched them on four corners and the slab was left until the plaster was set.
10. The upper and lower casts were removed from the slabs and their borders (*not base*) were trimmed with a fine trimmer. By this way the parallelism of upper and lower cast bases to the occlusal plane could be obtained.
11. Finally, the models were enumerated.

Ø **Preparation of models for evaluation:** Now the models were evaluated to observe the presence of Andrews' six keys of occlusion according to the methodology that was described by Andrews [9]. The facial axis of the clinical crown and its midpoint (the facial axis point), were marked with a pencil on each crown of each dental cast. The facial axis of the clinical crown represents the most prominent portion of the central lobe on the facial surface of each crown and can be determined by measuring the mesiodistal distance for each crown then dividing it; for molars, it represents the buccal groove that separates the two large facial cusps. The facial axis point was marked as the midpoint of the facial axis of the clinical crown and can be determined by measuring the occluso-gingival distance for each crown then dividing it (figure 6). The facial axis of the clinical crown served as the reference line from which crown angulation and inclination were measured.

Ø **Evaluation of the models:** The models were evaluated to observe the presence of all or some of the Andrews' six keys of occlusion [2] as follows:

Key I (Interarch Relationship): The occlusal relationship was evaluated from the buccal and lingual regions of the models. This key is composed of seven items as detailed below:

1st item: This item describes the position of the mesio-buccal cusp of the permanent upper 1st molar that should occlude in the groove between the mesial and middle cusp (developmental groove) of the permanent lower 1st molar, **2nd item:** The second item describes the position of the distal surface of the distobuccal cusp of the upper first permanent molar made contact and occluded with the mesial surface of the mesiobuccal cusp of the lower second molar, **3rd item:** This item describes the position of the mesio-lingual cusp of the upper 1st molar that should occlude in the central fossa of the lower 1st molar, **4th item:** In which the buccal cusps of the upper premolars should be related to the buccal embrasure of the lower premolars, **5th item:** According to the fifth topic, the lingual cusps of the upper premolars should have a cusp-fossa relationship with the lower premolars, **6th item:** In which the cusp of the upper canine should be related to the buccal embrasure of the lower canine and 1st premolar and the tip of its peak should be slightly mesial to the embrasure and **7th item:** This item describes the incisors position as key I, in which the upper incisors should overlap the lower incisors and midline should be coincide.

Key II (Crown Angulation): The following procedure was done to measure crown angulation for each tooth in the upper and lower arches:

1. The Ray Set® template was used to read the models' first order degree of rotation, necessary for placing the tooth at the center of the RTT base's second and third order system of movements.[6]
2. The cast was transferred to the device, then it had been adjusted by the rotating base so that the measured tooth fitted on 0°, the inclination adjustable screw was loosened to enable both the cast with the rotating base of the three-dimensional goniometer to move freely and by this way the tooth will inclined until the vertical rod that was fitted to the mandrel became tangent to facial axis point of the measured tooth. Then the adjustable screw was tightened.
3. The angulation adjustable screw was loosened, and then the vertical rod was aligned and superimposed on the facial axis of clinical crown. After that the adjustable screw was tighted, by this way the tip value was assessed directly from the angulation measuring scale.
4. After that each tip value of the measured tooth was checked with the range of Andrews' findings (mean and standard deviation); if the tip value within the range of Andrews' findings, it would considered as ***satisfactory (S)***, but if not it was considered ***non-satisfactory (N)*** [(4)] .

Key III (Crown Inclination):

1. To measure the toque value, the inclination adjustable screw was loosened and then the base in the 3rd order plane was tilted until the vertical rod (mandrel) and the laser beam were tangent to facial axis point. Then the adjustable torque screw was tightened.
2. The torque pointer was observed to read the value directly from the inclination measuring scale.
3. After that each torque value of the measured tooth was checked with the range of Andrews' findings (mean and standard deviation).

Key IV (Rotation): The rotation was determined by the following way:

1. A transparent acrylic plate was placed on the occlusal plane of the model.
2. The transparent acrylic plate in the canine region was perforated to prevent its displacement during tracing.
3. A fine marker pen was used to draw up a line that connected the contact points and buccal contour of the crowns.
4. After that the transparent acrylic plate was placed on the orthodontic diagram of Interlandi to draw the ideal arc for each model and accurately check out the angle of each crown.

Key V (Tight Contact Points): The existence of space between teeth was evaluated at the mesio-distal surfaces of the buccal side of the models.

Key VI (Curve Of Spee): The planes of occlusion found on the non-orthodontic normal models ranged from flat to slight curve of Spee. The occlusal plane that was greater than 2.5 mm was considered undesirable [(2)]. This was measured as follows:

1. A hard plastic plate was placed flat over the occlusal surfaces of the mandibular posterior teeth. Usually the template touched only the incisal edges of the mandibular incisors and the distal cusps of the permanent second molars.
2. A digital caliper was used to measure on each side, the depth of the curve of Spee was determined by measuring, in millimetres, the distance from the side of the template facing the teeth to the buccal cusp tip farthest away from it [(2)]. The mean of the values obtained for the right and left sides was recorded as the depth of curve of Spee.

Ø Statistical analysis: The data were analysed by using (Analyse-it version 2.20 Excel 12+). The usual statistical methods were used in order to analyze and assess results; they include:

Descriptive Statistics: Mean value, Standard deviation (S.D), Frequency distribution and percentage of Andrews' six keys.

Inferential Statistics: t-test and Pearson's Chi-square.

In the statistical evaluation, the following levels of significance are used:

$P > 0.05$ NS Non-significant
$0.05 \geq P > 0.01$ * Significant
$0.01 \geq P > 0.001$** Highly significant
$P \leq 0.001$ *** Very highly significant

RESULTS AND DISCUSSION

Based on the study of 120 non-orthodontic normal adults, Andrews's fully programmed appliance was developed. The prescription built into his appliance was based on the 1964 sample. The six keys of normal occlusion, which were used as the fundamental guidelines for determining the standard bracket prescription, were evaluated and calculated. Even after completing his study of 120 non-orthodontic normal casts, Andrews did not stop his search for better casts. In fact, to this day, the search for superior casts has continued. In 1988, the new norms for average angulation and inclination were published based on the best of 120 casts to that date [(2 , 9)]. This study has dealt with the distribution of Andrews' six keys of normal occlusion in Iraqi population. The sample selected in this study was composed of young adults, 18 – 25 years of age, because most of the

growth of facial area could be considered to be complete after the age of 18 year [10]. Two methods have been found for the comparison between the obtained values from this study and Andrews' findings. One of them was based on the study of Brangeli [4], who conducted the satisfactory and non-satisfactory evaluation which was tend to be more subjective. While the other method was based on Sebata [11], Watanabe [12], Currim and Wadkar [13] studies, which was more informative for the comparison between the study results and Andrews' [9] findings since it depends on a statistical method.

In this study we have found that 10% of the models meet all the occlusion findings of Andrews' six keys of normal occlusion, 5 keys (21%), 4 keys (34%), 3 keys (26%), 2 keys (8%) and finally 1 key (1%). This result does not agree with the work of Brangeli [4], who also used the six keys of Andrews as a reference for evaluation of normal occlusion. However, using a selected sample according to the classification of Angle [1], Brangeli [4] has found that the presence of 6 keys was zero, 5 keys (10%), 4 keys (15%), 3 keys (23%), 2 keys (34%) and 1 key (7%), whereas (11%) had none of the keys. When we compare between our study and Brangeli , we see that there is great difference. In our study great numbers of keys were achieved; because the samples of Brangeli may be not carefully selected due to limited time in his study, as he stated, and this led to found less satisfactory results in his study. It had been found that the higher percentage of males 20.4%, females 13.6% and total sample 34% were achieved 4 keys from Andrews' six keys of normal occlusion.

Again, significant difference had been not detected between males and females concerning the distribution of Andrews' six keys and the number of keys that have been achieved (table 1 & 2).

1- KEY I (Interarch Relationship):

This key was satisfactory in 72% of total sample; of which 45% were males and 27% females. In contrast, **Brangeli** [4] found this key was satisfactory in 66% of his study sample.

This study has found that the 1st and 7th items were satisfactory in all samples (100%) and this was perhaps because these items had been seen early and easily during sample selection, followed by 3rd item forming (95%), then 6th item (87%), after that 4th item (84%), then 2nd item (74%) and finally 5th item (63%).

In our study the intercuspation of premolars and canines were the most problem area, This may be due to crown inclination of the central incisors and canines in upper & lower arch which were inclined more labially and buccally than Andrews' average [9].

2- KEY II (Crown Angulation):

This key was satisfactory in 67% of total sample (41% males and 26% females), while Brangeli mentioned that this key was satisfactory in 43% of his sample.

On comparison of Andrews' original data, Andrews' data of 1988, Sebata's, Watanabe's, Currim's and Wadkar's data, with this maxillary angulation readings, we can conclude that our readings for the central incisor are in closest agreement with Watanbe's. Our readings for the lateral incisor and the 1st premolar best match with Andrews'; the canine and 2nd molar readings are much less comparable to all previous data, while the readings for 2nd premolar and 1st molar are nearest to Currim's and Wadkar's. On comparison of Andrews' original data, Andrews' data of 1988, Sebata's, Watanabe's, Currim's and Wadkar's data, with our mandibular angulation readings, we can conclude that our readings for the central incisor are in closest agreement with Sebata's. The readings for the lateral incisor best match with Currim's and Wadkar's; the canine and the 2nd molar readings are much less comparable to all previous data, while the readings for 2nd premolar are nearest to Andrews', Currim's and Wadkar's. Finally, the 1st premolar and 1st molar readings are in closest agreement with Andrews'(table 5) .

These findings suggest the possibility of a distinct racial and ethnic trait difference. To obtain excellent finishing, changes in the archwire, with extra treatment built in, might thus become routine procedure. Although the readings of P-value had shown different significant levels for the upper (lateral incisor, 2nd premolar and 1st molar), lower (central and lateral incisors, 2nd premolar and 1st molar); but the difference in mean angulation values for these teeth were not more than 1° when it compared with Andrews values (1988). Only the canine and second molar (*upper and lower*) had readings that differed by 2° or more. This would indicate that, if bracket prescriptions were to be altered, keeping in mind only the ideal values for the population in question, the prescription for the canine and 2nd molar should be altered to suit the Iraqi population. Similar suggestion also reported in the study of **Currim** and **Wadkar** [13].

In this study it has been found that there is no significant difference in crown angulation between males and females, except for the upper canine (*less angulated in females than males*) and second molar (*less angulated distally in males than females*) (table 3).

3- KEY III (Crown Inclination):

This key was achieved in 41% of total sample (28% males and 13% females). This key was satisfactory in 37% in the study of **Brangeli** [4].

On comparison of Andrews' original data, Andrews' data of 1988, Sebata's, Watanabe's, Currim's and Wadkar's data, with our maxillary inclination readings, we can conclude that our readings for the central incisor, 1st and 2nd molars are in closest agreement with Andrews'. The lateral incisor, canine, 1st and 2nd premolar readings are much less comparable to all previous data (table 5).

When the obtained values compared with Andrews' initial data [9], it had been found that the central and lateral incisors in the present study are more inclined, the canines and premolars are more upright, the first and second molars readings are comparable. This suggests a need for alterations in the archwire or bracket prescription for all teeth except the first and second molar.

On comparison of Andrews' original data, Andrews' data of 1988, Sebata's, Watanabe's, Currim's and Wadkar's data, with our mandibular inclination readings, it could be conclude that our readings for the central incisor and 1st premolar are much less comparable to all previous data. The lateral incisor and canine readings are in closest agreement with Sebata's. Our readings for the 2nd premolar, 1st and 2nd molars are best match with Currim's and Wadkar's.

In the mandibular arch, all teeth in our sample were more upright than those in Andrews' 1988 sample and his original study group of 1964, except for central and lateral incisors which had positive values. This finding again supports all earlier observations that indicate possible racial and ethnic factors contributing to the difference in readings. Changes in the archwire or the bracket prescription based on normal values are again called for.

In this study it has been found that there is no significant difference in crown inclination between males and females, except for the lower canine (*more upright in males than females*) (table 4). This key was achieved by the lowest percentage in the sample (table 2); this may be related to the fact that the Iraqi samples of our study were different racially than Andrews' American individuals. Yet, this study has found that Iraqi people had higher proclination in the upper and lower anterior teeth.

Finally, according to method of **Brangeli** [4], it has been found that some values of key II and III within the normal range of Andrews (*Satisfactory*), but this method was more subjective. Therefore, to be more precise in this study a statistical comparison had been employed (***Sebata,*** [11]***; Watanabe,*** [12]***; Currim and Wadkar*** [13]), to evaluate the values of angulation and inclination with Andrews' findings. It had been found that there were significant differences between them with different levels of P-value shown in table 5.

4- KEY IV (Rotation):

We cannot underestimate in any way the importance of no tooth rotation that provides the establishment of good occlusion. However, the value considered normal by **Andrews** [2] is very limited (2°). This value is different from those described by **Björk et al** [14] and **Cochrane et al** [15], who considered (15°) as an acceptable value.

In this study it had been found that the occurrence of tooth rotation more than 2° in the upper arch (41%) is less than in the lower arch (59%). The most affected tooth is the lower second premolar. This may be due to late time of eruption. This key showed that there was no significant difference between males and females (table 6).

This key was satisfactory in 62% of total sample, 41% were males and 21% females (table 2). In the sample of **Brangeli** [4], the rotation did not meet Andrews' findings (i.e. not satisfactory).

5- KEY V (Contact Point):

In this study it has been found that the occurrence of open contact point in the upper arch (73%) is more than in the lower arch (27%), and the most affected tooth is the upper canine. This may be due to tooth size discrepancy (*small lateral incisors*), and arch size discrepancy. There was no significant difference between males and females as shown in table 7.

This key was satisfactory in 57% of total sample, in which 35% were males and 22% females (table 2). Low values (10%) of tight contact point were only found by **Brangeli** [4]. In this study it was found that there were no crowding, but small spacing existed. This is probably due to presence of small buccal inclination or mild rotations.

Table 1: Comparison between males and females according to the number of achieved keys

SEX	GROUP						
	6 keys	5 keys	4 keys	3 keys	2 keys	1 key	Total
MALES	4	15	25	11	5	0	60
	(6.0%)	(12.6%)	(20.4%)	(15.6%)	(4.8%)	(0.6%)	
FEMALES	6	6	9	15	3	1	40
	(4.0%)	(8.4%)	(13.6%)	(10.4%)	(3.2%)	(0.4%)	
TOTAL	10	21	34	26	8	1	100
Chi-square	10.31						
P-Value	0.0668 (*NS*)						

Table 2: Comparison of Andrews' six keys of normal occlusion in males and females

SEX	GROUP						
	Key I	Key II	Key III	Key IV	Key V	Key VI	Total
MALES	45	41	28	41	30	60	245
	(44.2%)	(41.1%)	(25.2%)	(38.1%)	(35.0%)	(61.4%)	
FEMALES	27	26	13	21	27	40	154
	(27.8%)	(25.9%)	(15.8%)	(23.9%)	(22.0%)	(38.6%)	
TOTAL	72	67	41	62	57	100	399
Chi-square	3.38						
P-Value	0.6421 (*NS*)						

Table 3: Comparison of crown angulation between males and females

tooth no.	TEETH ANGULATION								
		UPPER ARCH				LOWER ARCH			
	Sex	Mean	S.D.	t-test	p-value	Mean	S.D.	t-test	p-value
1	Male	3.1	2.09	0.42	0.67	-0.45	1.5	0.49	0.62
	Female	2.9	2.7			-0.61	1.86		
2	Male	7.21	2.4	0.76	0.44	-0.5	2.81	-1.17	0.24
	Female	6.83	2.37			0.11	2.21		
3	Male	4.8	2.94	2.35	0.02*	0.45	2.91	0.95	0.34
	Female	3.26	3.56			-0.15	3.25		
4	Male	2.76	2.42	0.11	0.91	1.41	2.16	1.36	0.17
	Female	2.71	2.45			0.75	2.69		
5	Male	4.41	2.77	0.82	0.41	2.11	2.13	0.49	0.62
	Female	3.95	2.69			1.9	2.13		
6	Male	4.49	2.64	0.29	0.77	2.76	2.31	0.86	0.39
	Female	4.35	2.19			2.38	2.04		
7	Male	-1.85	2.95	2.04	0.04*	5.04	2.48	0.57	0.57
	Female	-3.24	3.86			4.75	2.46		

According to **Andrews** [2] it is possible, of course, to visualize and to find models which have deficiencies, such as the need for caps to provide proper contact, but these are dental problems not orthodontic ones. Sometimes there are compromises to be weighed, and these pose the true challenge to the professional judgment of the orthodontist. As responsible specialists, we are here to attempt to achieve the maximum possible benefit for our patients.

6- KEY VI (Curve of Spee):

The curve of Spee in the present sample averaged 1.36 mm which is within the acceptable range of 0 to 2.5 mm set by Andrews. This key was achieved in all samples (100%) with no significant difference between males and females as shown in table 8, while **Brangeli** [4] found that this key was satisfactory in 74%. This agrees with **Orthlieb** [16] who found no statistically significant difference in the radius of the curve of Spee between a males and females sample. **Ferrario et al** [17] reported that the occlusal curvature of the mandibular arch is not significantly influenced by sex. **Braun and Schmidt** [18] studied the differences in the curve of Spee between men and women and between the different Angle classifications,he found that the shape of the curve for males and females seemed to be identical, and no significant differences could be found among Class I, Class II division 1, or Class II division 2 patients.

Table 4: Comparison of crown inclination between males and females

tooth no	TEETH INCLINATION								
		UPPER ARCH				LOWER ARCH			
	Sex	Mean	S.D.	t-test	p-value	Mean	S.D.	t-test	p-value
1	Male	7.49	3.92	-0.72	0.47	4.85	5.97	-1.57	0.12
	Female	8.26	6.71			6.62	4.82		
2	Male	5.92	3.95	-0.16	0.87	2.4	4.6	0.91	0.36
	Female	6.08	6.34			1.52	5.01		
3	Male	-3.09	4.8	-0.12	0.90	-4.69	4.26	2.03	0.04*
	Female	-2.98	3.97			-6.57	4.9		
4	Male	-3.46	5.47	0.85	0.39	-13.19	5.5	0.43	0.66
	Female	-4.46	6.08			-13.65	4.81		
5	Male	-5.27	4.73	-0.17	0.86	-18.33	5.48	0.01	0.99
	Female	-5.1	5.01			18.34	6.17		
6	Male	-11.61	4.28	-1.13	0.26	-27.59	6.02	-0.14	0.88
	Female	-10.67	3.78			-27.35	10.76		
7	Male	-8.32	3.97	-1.29	0.19	-33.25	6.99	1.28	0.20
	Female	-7.21	4.59			-34.92	5.36		

Table 5: Different angulations and inclination values of several authors.

Author	Andrews 1989	Sebata 1980	Watanable 2001	Currim Wadkar 2004	Present study	Andrews 1989	Sebata 1980	Watanable 2001	Currim & Wadkar 2004	Present study
no. of sample	120	41	80	68	100	120	41	80	68	100
location	USA	Japan	Japan	India	Iraq	USA	Japan	Japan	India	Iraq
Angulation										
Tooth no.	Upper arch mean value					Lower arch mean value				
1	3.59	4.25	3.11	3.3	3.02	0.53	-0.48	1.98	-0.23	-0.52
2	8.04	5.74	3.99	4.27	7.06	0.38	-1.2	2.28	-0.43	-0.25
3	8.4	7.74	7.73	2.66	4.19	2.48	1.48	5.4	-1.17	0.21
4	2.65	3.51	4.67	2.6	2.74	1.28	2.52	3.8	-0.32	1.14
5	2.82	6.18	5.2	5.07	4.22	1.54	6.7	3.91	1.54	2.02
6	5.73	5.22	4.94	4.53	4.44	2.03	5.74	3.7	1.67	2.61
7	0.39	-0.3	4.09	3	-2.41	2.94	7.34	3.88	2.12	4.92
Inclination										
1	6.11	9.42	12.82	5.8	7.8	-1.71	3.55	0.71	1.36	5.56
2	4.42	7.48	10.35	4.44	5.98	-3.24	1.66	0.53	0.88	2.05
3	-7.25	0.67	-5.29	-5.99	-3.04	-12.73	-4.73	-11.13	-8.2	-5.44
4	-8.47	-6.46	-6	-8.4	-3.86	-18.95	-14.80	-18.38	-14.6	-13.38
5	-8.78	-6.46	-7.18	-9.88	-5.21	-23.63	-22.57	-21.81	-18.5	-18.33
6	-11.53	-1.73	-9.75	-11.27	-11.24	-30.67	-26.17	-31.23	-27.47	-28.14
7	-8.01	-2.97	-9.55	-9.95	-7.88	-36.03	-31.03	-32.9	-33.63	-33.92

Table 6: Comparison between satisfactory and non- satisfactory key IV in both gender

SEX	GROUP		TOTAL	Chi-square	P-Value	Sig*
	S	N				
MALE	41 (37.2%)	19 (22.8%)	60	2.55	0.1100	NS
FEMALE	21 (24.8%)	19 (15.2%)	40			
TOTAL	62	38	100			
S = Satisfactory						
N = Non satisfactory						

Table 7: Comparison of key V in males, females and total sample

SEX	GROUP		TOTAL	Chi-square	P-Value	Sig*
	S	N				
MALE	30 (34.2%)	30 (25.8%)	60	3.00	0.0833	NS
FEMALE	27 (22.8%)	13 (17.2%)	40			
TOTAL	57	43	100			
S = Satisfactory						
N = Non satisfactory						

Table 8: Comparison between the mean difference of key VI for males and females

Sex	Mean	S.D.	Min.	Max.
Male	1.31	0.4	0.5	2.5
Female	1.43	0.45	0.8	2.1
t-test	-1.35			
P	0.1804 (*NS*)			

Figure 1: Frontal view, **Figure 2:** Superior view and **Figure 3:** Lateral view of ***Three-Dimensional Goniometer*** **(wooden type).**

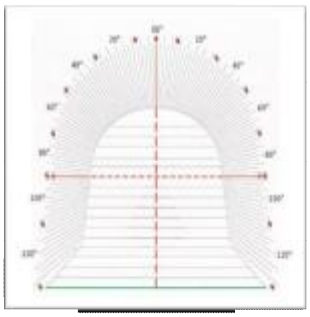

Figure 4: Plane rotation control (PRC) template or the so-called Ray set® template.

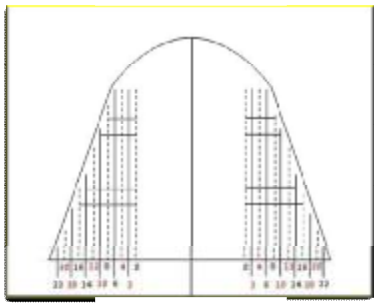

Figure 5: Orthodontic Interlandi diagram for tooth rotation measurement. [7]

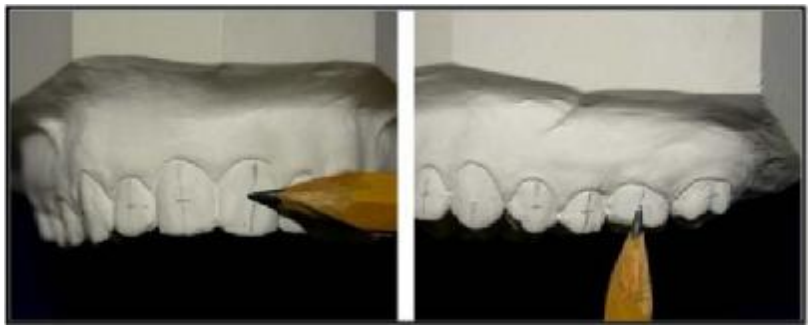

Figure 6: Tracing the facial axis of the clinical crown and determining the facial axis point in the upper anterior and posterior region of the model.

REFERENCES

1. Angle EH. Classification of malocclusion. Dental Cosmos1899; 4: 248-264.
2. Andrews LF. The six keys to normal occlusion. Am J Orthod Dentofacial Orthop1972; 62(3): 296-309.
3. Roth RH. Functional occlusion for the orthodontist: Part 1. J Clin Orthod1981a; 15:32-51.
4. Brangeli LAM. Prevalence of the Andrews' six keys of occlusion in young Brazilians with normal occlusion. Rev APCD 2001; 55(6):411- 45.
5. Foster TD. A text book of orthodontics 2nd ed. London: Blackell scientific puplication; 1985.
6. Melsen B, Biaggini P. The Ray Set: A new technique for precise indirect bonding. J Clin Orthod 2002; 36(11):648-54.
7. Interlandi S. Orthodontics: bases for Beginners. 4th ed. São Paulo: Artes Médicas 1999; 149-99, 263-83.
8. Moraes C. Study Models: indispensable element of diagnosis and restorative treatment plan in the specialties. Rev APCD 1969; 23(1): 1-8.
9. Andrews LF. Straight Wire: The Concept and Appliance. San Diego, Calif: LA Wells Co; 1989:25–33.
10. Graber TM. Orthodontics principles and practice. 3rd ed. Philadelphia: W.B.Saunders Company; 1972. p. 48.
11. Sebata E. An orthodontic study of teeth and dental arch form on the Japanese normal occlusions. Shikwa Gakuho 1980; 80:11–35.
12. Watanabe K, Koga M. A Morphometric Study with Setup Models for Bracket Design. Angle Orthod 2001; 71(6):499–511.
13. Currim S, Wadkar PV. Objective assessment of occlusal and coronal characteristics of untreated normals. Am J Ortho 2004; 125(5): 582-588.
14. Bjork A, Krebs AA, Solow B. A method for epidemiological registration of malocclusion. Ac Odontol Scand 1964; 22: 27-41.
15. Cochrane SM, Cunningham SJ, Hunt NP. A comparison of the perception of facial profile by the general public and 3 groups of Clinicians. J Adult Orthod Orthognath Surg. 1999; 14(4): 291-5.
16. Orthlieb JD. The curve of Spee: understanding the sagittal organization of mandibular teeth. Cranio 1997; 15: 333-340.
17. Ferrario VF, Sforza C, Poggio, CE, Serrao G, Colombo A. Three- dimensional dental arch curvature in human adolescents and adults. Am J Orthod Dentofac Orthop. 1999; 115: 401-405.
18. Braun ML, Schmidt WG. A cephalometric appraisal of the curve of Spee in Class I and Class II, Division 1 occlusions for males and females. Am J Orthod 1956; 42: 255-278.