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Comparison of the Dental Occlusion of Caucasians and Koreans : Implications for the Future of Orthodontics

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Since the inception of the edgewise orthodontic appliance by Dr. Edward Angle, many changes have occurred in edgewise appliance design and treatment technique[1-7]. A most significant event in the evolution of edgewise orthodontics was the development of the "Straight-Wire Appliance" by Dr. Lawrence Andrews in the early 1970's. The proliferation in the use of straight-wire appliances has culminated today with recent findings indicating that American Orthodontists use straight-wire appliances twice as often as other appliances[8-11].

Advantages and disadvantages of straight-wire appliances, as well as the various treatment methods, have been extensively analyzed and reviewed[12-17]. Critics of the "Straight-Wire Appliance" believe that no one single appliance can account for the infintismal variability in tooth size, shape and arrangement. In so keeping, the original Andrews' prescription, particularly for inclination and angulation, have been adjusted by various clinicians[18-20]. The proponents of the "Straight-Wire" philosophy argue, although there is individual variability in tooth morphology, there is more often concordance than discordance. Racial variations in facial pattern, tooth size and shape, and arch form have been demonstrated [23-25]. However, Andrews' "Six Keys to Normal Occlusion" study of 1972 was based upon an American Caucasian Sample. It is possible that inter-racial morphologic variability in tooth size and shape, tooth inclination and angulation, and arch form would be at a great enough threshold level to invalidate the "Straight-Wire" Appliance's clinical utility for races other than American Caucasians. Therefor, a valid argument against the "general" use of the "Straight-Wire Appliance" might be that it may not be applicable to races other than Caucasians.

Korean dentofacial morphology has been demonstrated to be different than that of American Caucasian[26]. In particular, the typical facial pattern of Korean is a Class III openbite and the typical dental pattern is an Angle's Class III with the vertical dental pattern ranging from normal to openbite, but not deepbite. Furthermore, the "optimal" dental morphology and occlusion for the Korean is pro-

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bably different than the Caucasian. That is, whereas the "optimal" occlusion for Caucasian possesses a "flat" curve of Spee, the Korean does not. In addition, the "optimal" occlusion for the Korean is one with bidental protrusion, i.e., increased inclination for the anterior teeth of Korean as compared with Caucasian. This, along with the typical dentofacial pattern of the Korean being Class III open or normal, may have important clinical ramifications. For example, Andrews' "flat" curve of Spee, as well as the inclination values used for Caucasians, may be contra-indicated for treatment of Koreans or other races. For example, "flattening" the curve of Spee for Koreans would probably make the skeletal and dental vertical patterns worse, i.e., produce a definite open-bite. For Koreans, the treatment goal is often to maintain the curve of Spee rather than "flatten" it.

In order to adapt the general "Straight-Wire" concept to the Korean population, some fundamental changes were in order. First, the Andrews' Plane(FA point) was discarded in favor of a new reference plane that allowed the curve of Spee of the Koreans to be maintained without "bending" a curve of Spee in the archwire, i.e., maintaining the original philosophy of "straight-wire"[26]. Incidentally, the Andrew Plane was not a straight line for Koreans because of the curve of Spee. The curve of Spee was considered, therefore, an optimal feature for the Korean dentition. Furthermore, since Dellinger's HOL line[27](i.e., line connecting the center of the first molar crown with that of the central incisor) was too gingival because of the Korean curve of Spee, bonding the "straight-wire" brackets to Korean premolar teeth via the principle of Andrew's plane was often difficult(Fig. 1). Because of the above cited difficulty, Lee[26,28] developed

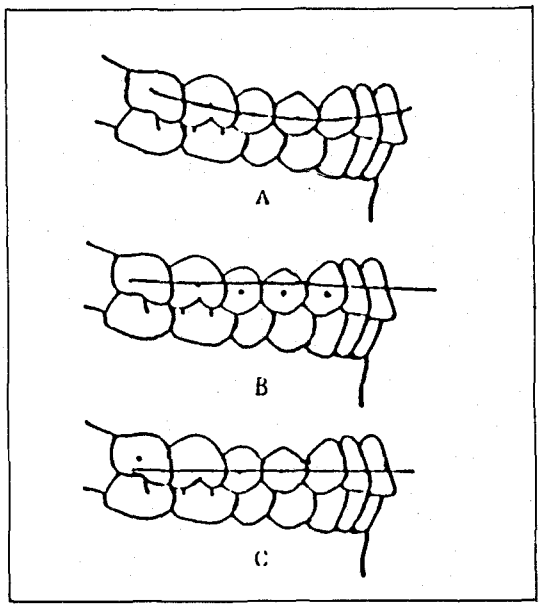

Fig. 1. Reference lines
A. Andrews Plane
B. HOL Line
C. Line for this study

a new reference line, which was straight for Koreans and it passed through the center of the premolars in order to maintain the patient's curve of Spee, and hence, permited "ideal" bracket placement for these theet(Fig. 1).

Based upon empirical data, an "Oriental Bracket" was developed(Oriental Bracket, Tomy Co., Japan) with a prescription that accounted for the dentofacial and dental patterns of Koreans. Korean differences in tooth size and shape, tooth angulation and inclination, arch form, and curve of Spee were some of the factors accounted for by the "Oriental Bracket".

The purpose of this investigation was to compare the "optimal" occlusions of Caucasians with that of Koreans based upon Andrews' philosophy developed in "The Six Keys", but using the new reference line. Data obtained from this study might be important

for development of bracket systems to account for racial variation. Also, information obtained from this study may have implications effecting both the future development of the "Straight-Wire Appliance" and orthodontics in general.

Methods and Materials :

Study models of 60 Caucasian adults (30 female, 30 male), used by Andrew in 1972, and 60 Korean adults (30 female, 30 male), were used for this study. They had "normal" occlusions without missing teeth or orthodontic treatment. To establish this study's upper reference line, a .018″×.022″ archwire, which passed across the center of the upper premolars and which was parallel to the occlusal plane, was fixed on the study models. A line was then drawn with a pencil. A lower archwire was fixed 2mm below the vertical overlap of the cusps of the upper arch with the lower arch and parallel to the upper reference line. Another line was then drawn with pencil(Fig. 2). The 2mm's was chosen to accommodate for the clinical possibility of lower brackets being contacted by the upper teeth facial cusps.

To study "bracket height", the distances from the reference line to the incisal edge of all teeth(i. e., mesiobuccal cusp tip of molars) were measured with a caliper.

To study crown angulation, the long axis of the crown (from the mid-point of the cervical margin to the mid-point of the incisal edge or cusp tip) and the buccal groove line of molars were drawn on the study models. In order to facilitate angular measurements on curved dental arches, photographs were taken of the anterior teeth area, the cainne area, the premolar and molar areas. The angles between

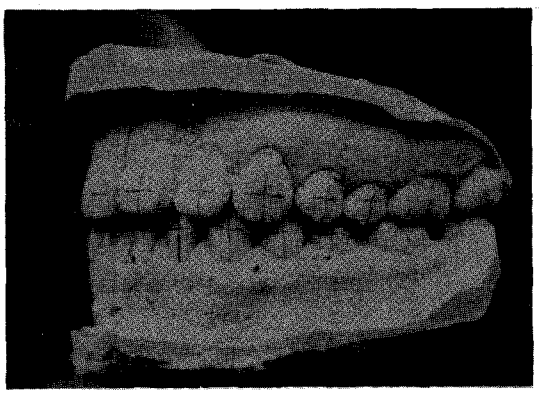

Fig. 2. Reference line and long axis of tooth on study model.

the occlusal plane(from the incisal edge to mesiobuccal cusp tip of first molar) and the long axis of crowns were measured on the photographs on the right side of the models only. A positive(+) angle indicated mesial angulation and a negative(−) angle indicated distal angulation.

To study crown inclination, Andrews' template(2~3mm thick, rigid, flat plastic) was used with a protractor on one side. A positive (+)angle indicated a labial or buccal inclination and a negative(−) angle indicated a lingual inclination.

To study that in-and-out relation, the study models were trimmed to the reference line and a smooth curve passing through the center of each point was drawn. The distance from this line to the mid-point of the facial surface of the crown was measured on one side. The models for the Caucasian sample were not trimmed ; the facial-lingual width of each tooth was measured with a caliper at the reference line and then one-half this measurement was used. As Schwaninger[29] noted, the in-and-out relation in the premolar and the molar areas was not effective unless an archwire was accurately fitted to the dental

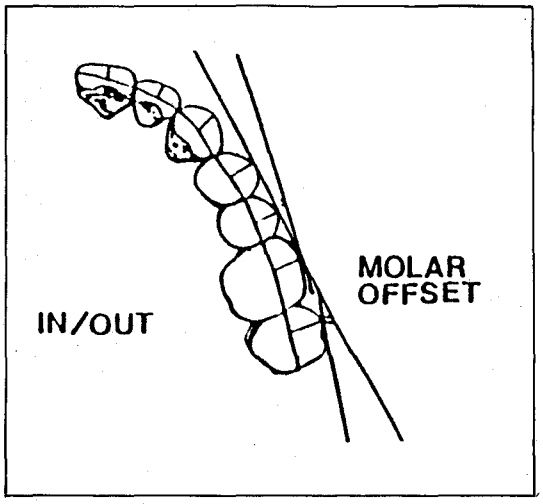

Fig. 3. The in-and-out and molar offset.

arch. Because no brackets were used in this study only the incisors and the canine were measured.

To study the rotation of molars, the occlusal surface was photographed. A line was drawn between the buccal surface of the first premolar and the buccal surface of mesiobuccal cusp of the first molar. Then, the angles between this line and one target to the facial surfaces of the first and second molars were measured. (Fig. 3).

Means and standard deviations were calculated and unpaired t-test's were performed.

Results :

"Bracket Height" : For both groups, the "bracket height" of the upper second molar was more occlusally positioned than for the other teeth. "Bracket heights" of the upper anterior teeth in the Caucasian were shorter, but those of the upper molars were longer than of the Korean. For the lower arch, all "bracket heights", except for the anterior teeth in the Caucasian, were shorter and the

Table 1. Means and Standard Deviations for "Bracket Heights"(mm)

Tooth		Caucasian(n=120)		Korean(n=120)		t value
		X	SD	X	SD	
Upper	I_1	3.55	0.51	3.86	0.53	4.62***
	I_2	2.86	0.55	3.17	0.47	4.70***
	C	3.63	0.56	3.80	0.52	2.44**
	P_1	3.79	0.62	3.84	0.60	0.63
	P_2	3.48	0.51	3.44	0.54	0.59
	M_1	2.77	0.50	2.57	0.41	3.39***
	M_2	1.76	0.80	1.61	0.65	1.59
Lower	I_1	3.68	0.52	3.66	0.79	0.23
	I_2	3.90	0.53	3.95	0.74	0.60
	C	4.09	0.61	4.40	0.59	4.00***
	P_1	3.50	0.54	3.90	0.59	5.48***
	P_2	3.12	0.53	3.58	0.55	6.60***
	M_1	2.72	0.70	3.41	0.63	8.03***
	M_2	3.25	0.67	3.56	0.47	4.15***

*P<0.05 **P<0.01 ***P<0.005

difference was possibly attributed to the difference in clinical crown length(Table 1).

"Crown Angulation" : In comparison of the angulations of the upper arches of the two groups, the Causcasian second molars were significantly more distally "tipped" than the of the Korean. In the lower arch, the Korean second premolar and first molar were more distally "tipped" than were the Caucasian(Table 2).

"Crown Inclination" : The upper and lower anterior teeth of the Korean were significantly more labially inclined, and the remaining teeth were less lingually inclined than those of the Caucasian(Table 3).

"In-and-Out" : The facial-lingual "thickness" of the anterior teeth of the two groups was different, but this depended largely on bracket height. Therefore, relative differences

Table 2. Means and Standard Deviations for "Crown AngulationL(°)

Tooth		Caucasian(n=60) X	Caucasian(n=60) SD	Korean(n=60) X	Korean(n=60) SD	t value
Upper	I_1	3.91	2.41	3.78	1.59	0.37
	I_2	4.12	3.15	3.73	2.74	0.72
	C	2.91	4.03	2.66	4.15	0.33
	P_1	4.18	3.66	2.91	3.27	2.00*
	P_2	5.69	3.85	6.45	3.18	1.18
	M_1	9.13	5.41	8.86	2.54	0.35
	M_2	3.12	7.81	9.81	2.73	6.26***
Lower	I_1	0.98	2.49	0.59	2.27	0.89
	I_2	1.40	2.71	1.65	2.45	0.53
	C	2.08	4.05	1.74	4.04	0.46
	P_1	2.86	4.52	2.45	4.07	0.52
	P_2	5.14	4.26	7.15	4.42	2.54**
	M_1	9.45	5.30	11.68	3.55	2.71***
	M_2	16.56	5.87	16.19	4.25	0.40

*P<0.05 **P<0.01 ***P<0.005

Table 3. Means and Standard Deviations for "Crown Inclination"(°)

Tooth		Caucasian(n=60) X	Caucasian(n=60) SD	Korean(n=60) X	Korean(n=60) SD	t value
Upper	I_1	+4.39	3.34	+10.05	3.63	8.89***
	I_2	+3.91	4.53	+7.64	3.43	5.08***
	C	−7.09	4.56	−1.51	3.87	7.23***
	P_1	−8.64	4.21	−4.50	3.66	5.75***
	P_2	−10.81	4.53	−3.82	3.64	9.32***
	M_1	−15.45	4.27	−5.72	2.97	14.49***
	M_2	−13.57	4.71	−4.51	4.07	11.27***
Lower	I_1	+0.97	4.03	+4.00	3.85	4.21***
	I_2	−1.33	3.58	+2.13	3.54	5.32***
	C	−8.83	4.02	−5.15	4.17	4.92***
	P_1	−15.34	5.21	−13.13	4.10	2.58***
	P_2	−19.30	5.51	−15.50	4.52	4.13***
	M_1	−26.96	6.03	−21.30	3.95	6.10***
	M_2	−30.54	6.40	−25.65	4.29	4.92***

*P<0.05 **P<0.01 ***P<0.005

of each tooth were more important than the "thickness" values. The in-and-out measurements of the two groups were similar(Table 4).

"Anti-rotation" : The molars of the Korean were significantly more rotated(i.e., distal surface lingual) than was that of the Caucasian. The shape of the dental arch in the Korean was possibly different from that in the Caucasian(Table 4).

Discussion :

The "bracket height" in the straight-wire appliance is important. Changes in the "bracket height" influences crown inclination and angulation. The "bracket height" values for the present study were generally similar to those of Tweed's[30] and were about 1mm shor-

Table 4. Means and Standard Deviations for "In-and-Out" of Anterior Teeth(mm) and Anti-rotation of Molars

Tooth		Caucasian(n=60) X	Caucasian(n=60) SD	Korean(n=60) X	Korean(n=60) SD	t value
Upper	I_1	2.57	0.21	2.98	0.39	7.17***
	I_2	2.49	0.20	2.86	0.40	6.41***
	C	3.35	0.10	4.15	0.49	12.39***
	M_1	13.46	6.67	15.73	6.22	1.93*
	M_2	18.98	7.48	22.30	6.60	2.58***
Lower	I_1	2.18	0.21	2.33	0.38	2.68***
	I_2	2.21	0.19	2.36	0.37	2.79***
	C	2.79	0.26	3.46	0.42	10.51***
	M_1	8.16	4.42	10.31	3.85	2.84***
	M_2	12.92	4.73	15.47	4.97	2.88***

*P<0.05 **P<0.01 ***P<0.005

ter than those of Root[18] and Alexander[31]. For the present study, the "bracket height" of the second premolar was 0.3~0.4mm shorter than that of the first premolar and the bracket height of the first molar was 0.7~0.8mm shorter than that of the second premolar. These agreed well with the general recommendation of Lindquist. The difference in "bracket height" for each tooth was similar to the findings of Alexander[31].

Because the "bracket height" of the upper central incisor for both Koreans and Caucasians was more incisally positioned than the FA point, a bracket positioned on the center of the crown would extrude the central incisors. Also, because there was a difference in the "bracket height" of the upper second molar and the upper first molar for Koreans and Caucasians a bracket positioned on the center of the second molar would extrude the second molar. This extrusion might cause a TM disorder.

In the comparison of the two groups, the "bracket geights" of the upper incisors and canines in the Caucasian were shorter, but those of the upper molars in the Caucasian were longer than those of the Korean. This meant that there was possibly a difference in the lengths of the crowns between Caucasian and Korean.

In the lower arch, the "bracket height" of Koreans and Caucasians for the lateral incisor was slightly longer than that of the central incisor and that of the canine was the longest. In comparison of the two groups, the "bracket heights" of the lower facial segment in Caucasians were shorter. These observations may be attributed to the greater clinical crown lengths of the Korean.

For crown angulation, the anterior teeth values were similar to those of other studies.[6,18,31] i.e., distal slant with a range of 2° to 4°. Parenthetically, mesially angulated canine brackets can cause the anterior teeth to be extruded in the initial treatment stage as suggested by McLaughlin[3]. The angulation of the posterior teeth varied greatly in many studies even within the same race. Clinically, anchorage requirements or treatment philosophy dictate angulation values. In this study, the upper second molar and the lower first molar in the Caucasian were more upright than those in the Korean. In general, the factors that could influence crown inclination are tooth position, crown contour, and occlusal plane[31]. In addition, Vardimon[25] reported that the buccolingual direction of the root in the alveolar bone was a significant factor. Because the labial or buccal contour of the crown was not a flat or regular curve, there were differences reported based upon measurement methods ; measurement errors were also great. Fore example, the inclinations of the upper central incisor for Caucasian varied : Andrews[4,5] 7°, Ricketts[32,33] 22°, Alexander[31] 14°, Root[18] 14°, and Roth[22] 12°.

In this study, the probable reason for the small inclination value of the upper anterior teeth in Caucasian compared with other studies was that the reference line was more incisally positioned for this study. In comparison of the two groups, the inclinations of the upper and lower anterior teeth in the Korean sample were significantly greater. These observations corresponded with Lee's cephalometric study[28] of Korean. The remaining teeth, except for the anterior teeth in the Korean, were less lingually inclined. A possible explanation could be a difference in clinical crown height, or "bracket height", or both.

The relative differences in "in-and-out" relation of each tooth varied in similar amounts

in the two groups. The upper lateral incisor was only 0.1mm thicker than the central incisor, but the upper canine was about 1.0mm thicker than the upper lateral incisor. This meant that more canine offset and less lateral offset was necessary compared with a routine first order bend of the archwire[34].

The anti-rotations of the molars in Korean were slightly larger. This finding indicated the possiblility that the shape of the dental arch might be different, but this could not be confirmed by this study.

Based on this study, it was concluded that the straight-wire prescription for Korean is different than that of Caucasian.

Implications :

America is considered a "melting pot" ; it is composed of people of all races. It is possible that different "Straight-Wire" appliance prescriptions would be better for one American sub-group or race than the single, generic "straight-wire" prescription of Andrews. Application of the original "Straight-Wire" prescription of Andrews for all racial groups may be counter-productive to attaining treatment goals specific for each race or sub-group. For Korean's, the traditional Andrew prescription would not provide enought inclination for the anterior teeth ; this race is bidentally protruded. Further, the traditional prescription would worsen this group's skeletal and dental vertical patterns, i.e., produce an openbite.

More important than even the aforementioned considerations is, this study might provide us with an answer to the question of the future of orthodontics ; not merely a look at orthodontics in the next one or two decades, but in the next quarter to half century. Perhaps, orthodontists will be able to enter pre-treatment diagnostic quantitative data for each patient relative to facial type, dental malocclusion, psycho-social factors, etc. A computer could then analyze and formulated a treatment plan and produce a bracket prescription specific for each patient. Bracets could be set-up for indirect bonding at prescribed heights that are specific for each patient. Individualized inclinations, angulations, in-out's, arch forms, bracket heights, etc., could be made to ost ideally accomplish the treatment goals for each patient.

Conclusions :

1. In the upper arch, the "bracket heights" of the incisors in the Caucasian were significantly shorter, but the bracket heights of molars in the Caucasian were longer than those in the Korean. In the lower arch, all bracket heights except that of the anterior teeth in the Caucasian were significantly shorter. These observations indicated that the clinical crown length might be shorter in the Caucasian than that in the Korean.
2. The crown angulation of the upper second molar in the Caucasian was significantly more upright than in the Korean.
3. The crown inclination of the upper and lowere anterior teeth in the Korean were more labially inclined and the posterior teeth in the Korean were less lingually inclined that in the Caucasian.
4. In both the Caucasian and the Korean, the relative differences of thickness in each tooth varied by similar amounts.
5. The rotation of the molars in the Korean were slightly greater. The shape of the dental arch might be different between Korean and Caucasian.

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