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The Effect of Variations in the Vertical Position of the Bracket on the Crown Inclination

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Precise bracket positioning is essential in modern orthodontics. However, there can be alterations in the vertical position of a bracket due to several reasons.

The purpose of this study was to evaluate the effect of variations in the vertical bracket position on the crown inclination in Korean patients with normal occlusion.

From a larger group of what was considered to be normal occlusions obtained from the Department of Orthodontics, College of Dentistry, Seoul National University, each of the final 10 subjects (6 males and 4 females, with an average age of 22.3 years) was selected. The dental models of each of the subjects were scanned three-dimensionally by a laser scanner, and measurements drawn from these were made on the scanned dental casts of the subjects were input into the computer program. From this the occlusal plane and the bracket plane were determined. The tooth plane was then constructed to measure the crown inclination on the bracket plane of each tooth. From a practical standpoint, information was obtained on the extent to which the torque of a tooth would be changed as the bracket position was to be moved vertically (in ±0.5 mm, ±1.0 mm, ±1.5 mm) from its ideal position.

A one way analysis of the variance (ANOVA) was used to compare each group of the different vertical distances from the bracket plane on a specific tooth. Duncan's multiple comparison test was then performed.

There were statistically significant differences in the crown inclination among the groups of different vertical distances for the upper central incisor, upper lateral incisor, upper canine, upper first and second molars, lower first and second premolars, and lower first and second molars ($p<0.05$).

On the upper anterior teeth, upper molars, lower premolars and lower molars, the resultant torque values due to the vertical displacement of the bracket were different depending on the direction of the displacement, occlusal or gingival.

This study implies that the torque of these teeth should be handled carefully during the orthodontic treatment. In circumstances in which the bracket must be positioned more gingivally or occlusally due to various reasons, it would be useful to provide the chart of torque alteration of each tooth referred to in this study with its specified bracket prescription.

Key words : Crown inclination, Torque, Normal occlusion, 3D scanner

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The aim of modern orthodontics has been summarized as the creation of the finest occlusal relationship within the framework of acceptable facial aesthetics and the stability of the occlusal result.[1] This requires positioning the crown of each individual tooth in its appropriate position for optimum function and appearance, which makes the precise bracket positioning of the bracket imperative. The clinical implications of an error in bracket placement are unstable teeth positions, lack of root paralleling, food impaction due to marginal ridge discrepancies, and the failure to establish the very specific occlusal scheme of canine rise or mutually protected occlusion.[2] Thus, to control teeth positions efficiently in the three mutually perpendicular planes of space, preadjusted appliances were developed.

The Andrews' preadjusted appliance, the straight-wire appliance (SWA), has found widespread acceptance and has been described by Swain[3] as consisting of the placement of an individual bracket at a prescribed position on the crown of a tooth and using a straight-wire to complete treatment effective in 95 per cent of patients. Precision in bracket placement is essential in this system since the control of the tooth position lies within the bracket rather than due to bends introduced into the archwire. The importance of the accurate placement of preadjusted brackets has been emphasized by many practitioners.[3-10] Journal articles have described many direct and indirect bonding techniques in an effort to improve initial placement accuracy.[11]

Many authors have presented their own standards of bracket positioning.[12-16] Furthermore, they have recommended to give slight variations in the vertical position of brackets for the elimination of occlusal interferences and the correction of openbite or deepbite.[13,14]

Among the several parameters of teeth positions, the axial positioning of teeth in the faciolingual plane is the most controversial. For example, the faciolingual slot angulation for central incisor brackets varies by more than 20° among several standard prescriptions that are available today.

In addition to the reasons described above, clinicians can make an error in vertical bracket positioning when brackets are placed upon the teeth, whether one uses a direct or an indirect bonding technique.[11] Incorrect slot inclination has the potential to influence the final tooth position. Bracket slot inclination varies both in placements performed by the same practitioner and between different operators.[17] Andrews[18] stated that clinicians could position brackets within a 2° and 0.5mm tolerable range of error for angles and linear positions of the bracket, respectively. Balut et al.[2] showed that a mean of 0.34 mm for the vertical discrepancies was found in the placement of the orthodontic brackets. As the bracket is moved occlusally or gingivally, the convex nature of the labial or buccal surface of the teeth reflects differences in torque values.[19]

Besides operator errors, even under the best of circumstances, ideal bracket placement during initial bonding is often impossible because of limitations brought on by the existing malocclusion.

The superior/inferior location of the bracket on the curvature of the labial surface is known to affect the faciolingual orientation of a tooth.[8,18] Although it is well known that a vertical deviation in bracket placement will influence the horizontal position and the torque[20], only little information about the actual degree of these variations is available. One reason for this relatively meager quantity of data is the lack of a precise description of the variations in the normal human crown morphology[21], the other is the absence of an effective research methodology.[22-24]

There have been many studies about evaluating the influence of change in the vertical position of brackets on the crown inclination[2,8,21,25], and these were performed on dental models directly. To overcome the errors arising from the manual analysis of dental models, a three dimensional dental model analysis system made possible by a three dimensional scanner and computer program was introduced in this study.[26-31]

The purpose of this study was to evaluate the effect of variations in the vertical bracket position on the crown inclination in the normal occlusion of Korean patients.

MATERIALS AND METHODS

1. MATERIALS

From two hundred normal samples from the Department of Orthodontics, College of Dentistry, Seoul National University, ten study casts were selected. Among the subjects, six were males and four were females. The mean age of the sample group was 22.3 years and the standard deviation was 2.1 years. The study models were chosen on the following criteria :

1) No previous orthodontic treatment
2) Normal anatomic occlusion
3) Angle Class I molar relationship
4) All teeth were in occlusion, no rotations, diastemas present
5) 2 mm ≦ overbite, overjet ≦4 mm
6) Crowding less than 3 mm
7) Minimum attrition
8) No artificial crowns present
9) No restorations replacing the incisal edge of anterior teeth or buccal cusps of posterior teeth

2. MATERIALS

All impressions of the subjects were taken with Kalginate impression material (Teledyne Water Pik, U.S.A.). All models were poured in New Plastone dental stone(GC Corp., Japan).

The Dental models were scanned three-dimensionally by Cyberware MS scanner(Fig. 1). This laser scanner was of the non-contact type and the resolution was 0.01 mm. Scanned upper and lower models and the planes on which were shown in Fig. 2. Measurements were made on the scanned dental casts of the subjects in the computer program.

In three dimensions, three points are required to define a plane. The occlusal plane(Op) was established using the incisal edges of the central incisors and the mesiobuccal cusp tips of the second molars(Fig. 3, A).

By connecting the left and right midcrown molar points, which is 2.5 mm distant from the occlusal plane on the maxillary teeth, 2.0 mm on the mandibular teeth respectively, and the midcrown point of the average of the left and right central incisors, which is 4.5mm distant from the occlusal plane on the maxillary teeth, and 4.0 mm on the mandibular teeth respectively, a plane could be constructed. This plane was called the bracket plane, or the Bp. The distance from the occlusal plane was determined from several bracket placement charts.[7,15,16] In the premolars and the first molar, the Bp was corrected in consideration of the compensating curve on the maxillary arch and curve of Spee on the mandibular arch.

The tooth plane(Tp) was constructed by designating three points on the labial or buccal surface of each tooth(Fig 3, B). This plane paralleled the labial or buccal long axis of the clinical crown. The crown inclination or torque angle to be measured was formed by the intersection of a line perpendicular to the occlusal plane and a line tangent to the intersected point of the Bp and Tp on the labial or buccal surface of each tooth.[32] As errors can occur due to irregularities on the tooth surface, the average convexity was considered in the range of ± 1.5 mm from the intersection point, as the average height of a bracket is 3 mm.

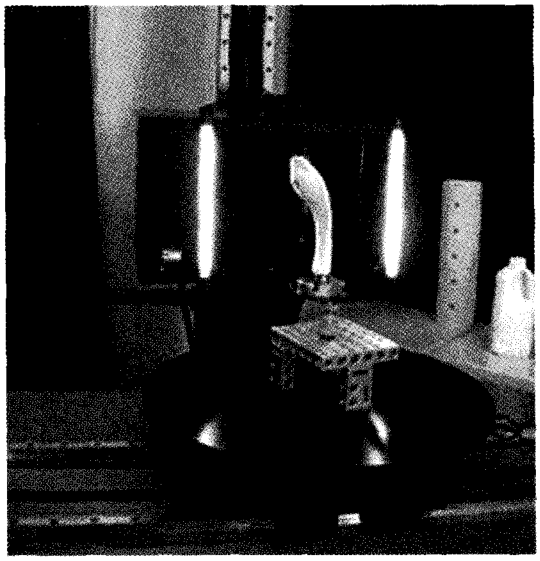
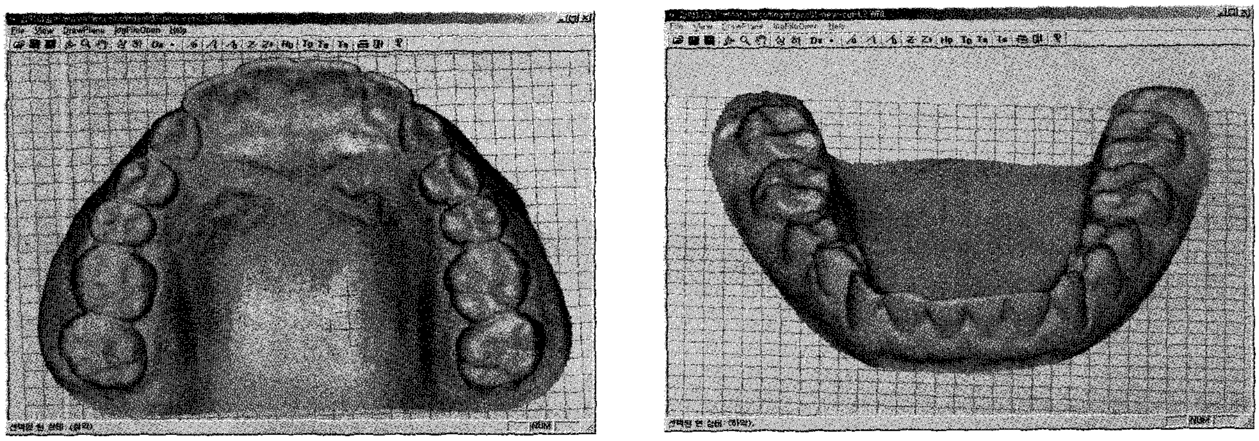
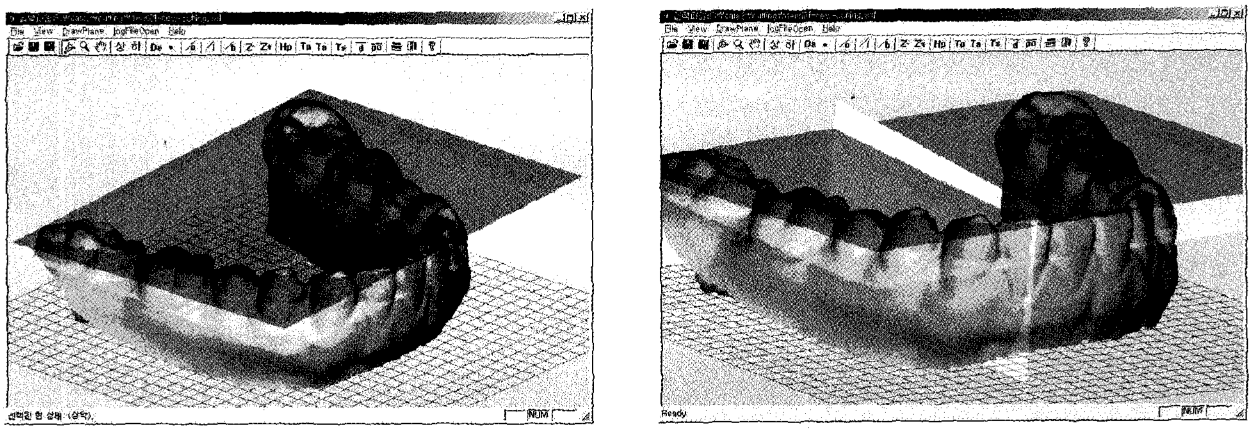


Fig. 1. Cyberware MS scanner



(A) (B)

Fig. 2. Scanned dental casts. A, maxillary model ; B, mandibular model



(A) (B)

Fig. 3. Construction of planes. A, occlusal plane and bracket plane ; B, tooth plane

From a practical standpoint, information was obtained on the extent to which the torque of a tooth would be changed if a bracket was to be positioned vertically (in 0.5 mm, 1.0 mm, 1.5 mm increments) from its ideal position. Each measurement was done five times on each tooth and the average score was recorded.

3. STATISTICAL ANALYSIS

As the Wilcoxon signed rank test showed no differences between the mean torque values of the right and left tooth crowns, the two segments were combined for better statistical evaluation. A one way analysis of the variance(ANOVA) was used to compare each group of differingent vertical distances from the bracket plane on each specific tooth. Differences with a p-value less than 0.05 were regarded as significant. Duncan's multiple comparison test was performed. And a computerized statistical analysis carried out with SPSS program.

Table 1. Crown inclination changes for different vertical distances from bracket plane in upper anterior teeth

	Mean ± SD	F	Duncan grouping+
Upper central incisor			
−1.5	19.62 ± 3.95		C
−1.0	18.73 ± 1.54		C
−0.5	17.96 ± 2.92		BC
0.0	15.92 ± 3.87	5.22*	AB
0.5	15.87 ± 2.32		AB
1.0	15.63 ± 3.48		AB
1.5	16.40 ± 3.06		A
Upper lateral incisor			
−1.5	19.88 ± 4.29		B
−1.0	17.06 ± 2.92		A
−0.5	16.06 ± 3.99		A
0.0	15.47 ± 2.94	4.99*	A
0.5	14.69 ± 2.60		A
1.0	14.61 ± 4.35		A
1.5	15.28 ± 4.31		A
Upper canine			
−1.5	9.42 ± 6.70		C
−1.0	8.63 ± 7.10		C
−0.5	7.98 ± 6.68		C
0.0	6.66 ± 6.52	5.53*	BC
0.5	2.48 ± 8.69		AB
1.0	1.43 ± 10.04		AB
1.5	−1.83 ± 10.30		A

+ Means with the same letter are not significantly different at the 0.05 level.
* $p < 0.05$

Table 2. Crown inclination changes for different vertical distances from bracket plane in upper posterior teeth

	Mean ± SD	F	Duncan grouping+
Upper first premolar			
−1.5	−3.50 ± 10.80		A
−1.0	−4.55 ± 8.83		A
−0.5	−4.61 ± 7.24		A
0.0	−5.64 ± 5.08	0.31	A
0.5	−5.02 ± 7.12		A
1.0	−2.81 ± 8.08		A
1.5	−3.65 ± 7.05		A
Upper second premolar			
−1.5	−3.10 ± 11.80		B
−1.0	−5.30 ± 9.61		AB
−0.5	−6.80 ± 7.92		AB
0.0	−9.35 ± 3.18	1.41	A
0.5	−4.99 ± 9.09		AB
1.0	−3.86 ± 8.80		AB
1.5	−8.04 ± 6.17		AB
Upper first molar			
−1.5	−5.90 ± 9.78		B
−1.0	−6.22 ± 7.87		B
−0.5	−7.59 ± 5.32		B
0.0	−9.41 ± 4.37	4.35*	B
0.5	−9.62 ± 4.13		B
1.0	−10.45 ± 4.77		B
1.5	−14.86 ± 7.49		A
Upper second molar			
−1.5	−5.41 ± 9.85		D
−1.0	−7.55 ± 9.91		CD
−0.5	−10.22 ± 11.61		CD
0.0	−14.37 ± 10.13	6.16*	BC
0.5	−18.77 ± 17.24		AB
1.0	−23.40 ± 11.72		A
1.5	−21.11 ± 15.22		AB

+ Means with the same letter are not significantly different at the 0.05 level.
* $p < 0.05$

RESULTS

Table I to IV list the means and standard deviations of measurements. The means marked by the same letters are not significantly different at the 0.05 level.

On the bracket plane, the upper central and lateral incisor and canine had positive torque values (central : 15.92 ± 3.87°, lateral : 15.47 ± 2.94°, canine : 6.66 ± 6.52°). The mean crown torques for the upper first premolar, second premolar, first molar, and second molar were −5.64 ± 5.08°, −9.35 ± 3.18°, −9.41 ± 4.37°, −14.37 ± 10.13°, respectively. The lingual crown torque of the lower teeth increased progressively from −0.51 ± 6.19° for the central incisor to −30.79 ±

Table 3. Crown inclination changes for different vertical distances from bracket plane in lower anterior teeth

	Mean ± SD	F	Duncan grouping+
Lower central incisor			
−1.5	2.13 ± 6.68		A
−1.0	1.68 ± 7.44		A
−0.5	−0.47 ± 6.80		A
0.0	−0.51 ± 6.19	1.12	A
0.5	−1.58 ± 5.68		A
1.0	−0.99 ± 5.63		A
1.5	−1.71 ± 6.37		A
Lower lateral incisor			
−1.5	2.23 ± 5.75		B
−1.0	1.91 ± 6.30		AB
−0.5	−0.31 ± 5.87		AB
0.0	−0.30 ± 5.42	1.78	AB
0.5	−1.67 ± 5.22		AB
1.0	−1.73 ± 5.76		AB
1.5	−1.97 ± 6.19		A
Lower canine			
−1.5	−6.38 ± 3.80		AB
−1.0	−5.14 ± 3.97		B
−0.5	−6.65 ± 5.20		AB
0.0	−8.03 ± 6.36	1.94	AB
0.5	−8.32 ± 5.62		AB
1.0	−10.27 ± 6.04		A
1.5	−9.79 ± 9.20		A

+ Means with the same letter are not significantly different at the 0.05 level.

* $p < 0.05$

Table 4. Crown inclination changes for different vertical distances from bracket plane in lower posterior teeth

	Mean ± SD	F	Duncan grouping+
Lower first premolar			
−1.5	−11.68 ± 6.26		C
−1.0	−14.31 ± 2.81		BC
−0.5	−16.24 ± 5.59		ABC
0.0	−21.13 ± 4.88	3.16*	AB
0.5	−20.12 ± 13.88		AB
1.0	−20.54 ± 14.78		AB
1.5	−23.25 ± 16.09		A
Lower second premolar			
−1.5	−16.86 ± 4.18		C
−1.0	−19.98 ± 3.76		BC
−0.5	−22.73 ± 4.20		ABC
0.0	−27.18 ± 5.45	3.68*	AB
0.5	−30.45 ± 4.77		A
1.0	−28.71 ± 21.96		A
1.5	−30.40 ± 22.70		A
Lower first molar			
−1.5	−24.52 ± 3.46		E
−1.0	−26.94 ± 4.26		DE
−0.5	−29.09 ± 5.03		D
0.0	−32.90 ± 7.49	36.84*	C
0.5	−35.92 ± 4.69		C
1.0	−40.48 ± 7.46		B
1.5	−44.95 ± 4.42		A
Lower second molar			
−1.5	−13.89 ± 24.11		E
−1.0	−22.88 ± 16.23		D
−0.5	−28.29 ± 7.84		CD
0.0	−30.79 ± 6.81	13.65*	CD
0.5	−33.99 ± 6.03		BC
1.0	−40.87 ± 6.24		AB
1.5	−43.34 ± 6.12		A

+ Means with the same letter are not significantly different at the 0.05 level.

* $p < 0.05$

6.81° for the second molar.

ANOVA demonstrated that there were statistically significant differences among the groups of differing vertical distances for the upper central incisor, upper lateral incisor, upper canine, upper first and second molars, lower first and second premolars, and the lower first and second molars($p<0.05$). Measurements on the upper premolars, lower incisors and lower canine showed no significant differences among the groups($p>0.05$).

A bracket displacement of 1.5 mm gingivally from the bracket plane for the upper central incisor, lateral incisor, canine, first molar and second molar can cause 3.7°, 4.41°, 2.76°, 3.51°, 8.96° of change in the resultant torque respectively. In the lower arch, 9.45° of change was recorded for the first premolar, 10.32° for the second premolar, 8.38° for the first molar, and 16.9° for the second molar, which were higher values than those recorded among the upper teeth.

DISCUSSION

Toward the end of a treatment program, the teeth must be brought as close as possible to their final and functional positions before debonding. This necessitates the perfect alignment of the marginal ridges, contact points, and the roots of the teeth. Factors such as errors in the bracket placement, tooth irregularities, and variations in tooth structure make it difficult to achieve these goals accurately with the preadjusted orthodontic appliances.[2]

In the six keys to normal occlusion, Andrews[12] stated that most maxillary incisors had a positive inclination–the centrals more positive than the laterals–and that the mandibular incisors had a slightly negative inclination. Compared with the crown inclination value on the bracket plane, Andrews' sample showed the result similar to that of this study for the maxillary and mandibular incisors.

Andrews also stated that the crown inclinations of the maxillary canines and premolars were negative and quite similar. However, in this study, the maxillary canines showed a positive torque value. This discrepancy may in part be explained by the method used to describe the occlusal plane.

Andrews used the plastic templates as representatives of each arch's occlusal plane. While the occlusal plane in this study was established using the incisal edges of the central incisors and the mesiobuccal cusp tips of the second molars through a computer program. These different methods to define the occlusal plane could contribute to the discrepancies in the results.

Andrews demonstrated that the inclinations of the maxillary first and second molars were similar and negative, but slightly more negative than those of the canines and premolars. This was coincident with the results of this study. However, Kim et al.[33] reported that the crown inclinations of the maxillary premolars had a greater negative value than those of the maxillary molars. This was due to the differences in the area of measurement. The molars were more negative because Andrews' sample and those in this study were measured from the developmental groove. On the other hand, Kim et al.[33] measured the crown inclinations from the prominent facial ridge, from which the canines and premolars were measured.

The inclinations of the mandibular crowns in this study were progressively more negative from the incisors to the second molars, which was consistent with the results from Andrews' research.

The crown inclinations on the occlusal side from the bracket plane of the upper canine, the gingival side of the upper premolars, along all the buccal surface of the upper second molar, the occlusal side of the lower canine and premolars, and the gingival side of the lower second molars showed a wide range of standard deviation. This reflects a morphological variation in those areas. The dispersion among the mean torque values indicates that individual variations should be taken into account when treating patients.

The facial crown contour is important in the selection of the tangent point used for the constructiong of the torque angle. A tangent is defined by "making a contact at a single point on a linear curve touching but not intersecting." However, as the facial surface of a tooth does not describe a uniform curve, the ability to draw a unique tangent at a given point is doubtful. Precision in delineating the tangent line was found to decline along the following sequence : premolars, canines, incisors, molars.[34]

Inherent in the straight–wire appliance concept is the supposition that the facial surface of each type of tooth has the same curvature in all persons. Thus, once the ideal position of each tooth is known, a set of preadjusted brackets can be designed to achieve this tooth position. It does not matter how much variation exists between the facial surface contour of any specific tooth type and that of another tooth type. One can compensate for whatever difference exists between the two by varying the slot positions accordingly. What is important is that all of the teeth of the same type in all patients are, in fact, alike(i.e., central incisor facial contours can vary from lateral incisor facial contours, but all central incisor facial contours must be alike and all lateral incisor facial contours must be alike, etc.) When this is not the case, the standardized bracket torques will produce different torques on different teeth of the same type. This, in turn, will require more or less torque via third-order bends or a method of varying bracket slot positions between patients to compensate for differences in the facial contours of the same types of teeth in different patients.[35]

Vardimon et al.[34] evaluated the torque angles in reference to straight-wire appliance theories. According to that study, intertooth torque correlations demonstrated a systematic arrangement defined as follows : (1) a lower torque value for a known tooth indicates a lower value for a predicted tooth, (2) neighboring teeth show the strongest coefficient of correlation, and (3) intertooth torque correlations are ranked according to dental fields, showing a similar genetic pattern to tooth morphology.

In the upper central incisor, a 1mm deviation gingivally from the bracket plane produced a 2.87° torque change labially, which was significantly different. On the other hand, a 1mm deviation incisally resulted in a 0.3° torque change lingually, which showed no significant difference. In the upper lateral incisor, a 1mm devitation gingivally resulted in an approximately 1.6° torque change and a 1mm deviation incisally incurred a 0.2° lingual change, both of which were not significantly different. This implies that the resultant inclination values due to the vertical displacement of the bracket are different depending on the occlusogingival position, especially when the bracket position is deviated gingivally.

In the upper arch, central incisor, lateral incisor, canine, first molar and second molar, there were statistically significant differences in crown inclinations among the groups of differing vertical distances from the bracket plane($p<0.05$). On the contrary, measurements on the upper first and second premolars resulted in no significant differences among the groups ($p>0.05$). This indicates that the amount of change in the convexity of the upper premolar is relatively constant throughout the buccal surface.

Balut et al.[2] showed that the teeth which presented the most difficulty in vertical bracket placement were the upper second premolars, possibly because of the length of their clinical crowns (which are sometimes short). According to the results of this study, the bracket positioning errors due to the reasons stated above do not make any significant difference to the crown inclination.

In the lower arch, central and lateral incisor, and canine, there were no statistically significant differences among the groups of differing amounts of vertical displacement. On the other hand, the premolars and molars showed significant differences among these groups.

Meyer and Nelson[8], who relied on a mathematical calculation for their estimations, showed that an error of 3 mm vertically in bracket placement on a mandibular first premolar can result in a 15° torque alteration. This study concurred with results, in which the mean torque value changed in the amount of approximately 12°.

In the lower second premolar, the mean crown inclination change due to bracket displacements from the bracket plane in the distances of 0.5 mm, 1.0 mm, 1.5 mm gingivally was respectively 4.4°, 7.2°, 10.3°. Germane et al.[35] reported that a bracket displacement of 3 mm on a lower second premolar can cause a 25.8° change in the resultant torque. In this study, the amount of change was 29.5°.

The error in the placement of brackets appears to be more closely related to the skill of the clinician, the tooth structure, the size of the clinical crowns, and the malposition of the tooth in the dental arch. In some cases, the clinician has to compromise and place the bracket more gingivally because of interference with the long cuspal heights on the opposing posterior teeth.[36] This is especially in the case in the of lower molar teeth.

In this study, the lower first molar showed an average 3° alterations (more lingually) in crown inclinations every

0.5 mm increasing gingival displacement from the bracket plane. Clinicians can refer to this value with orthodontic treatment. In the lower second molar, the amount of torque change was greater in a bracket displaced more gingivally compared with that of the lower first molar.

As any effect of the bracket/tooth interference was excluded from this study, the actual clinical accuracy of bracket positioning on the posterior teeth would be significantly worse on a patient. Thus, variability may be greater than stated here, when brackets are placed directly in a clinical context.

In the present study as well as in the aforementioned publications, all the values were estimated under the precondition that no play existed between the wire and the bracket, ie, full-size wires were applied. Although this is rarely the case, especially in a sliding technique, it is nevertheless the premise under which the preadjusted appliances are fabricated, and ideally it is thought to finish cases in a full arch. The impact of the play between wire and bracket was computed by Meyer and Nelsen[8]. They demonstrated that the play was of the same magnitude as the consequence of an average variation in the vertical displacement of a bracket. Although this makes the bracket choice and placement less critical, but it also indicates a lack of precision.

Errors within the slot inclination arising from the incorrect placement of brackets can not be expected to be expressed clinically due to the labiolingual deviation angle. In the clinical situations, the effect of the deviation angle is influenced not only by the geometry of the archwire to bracket slot interface, but also by the archform and position of adjacent brackets on teeth as the archwire does not act in isolation on a single tooth.[17]

Before using a certain torque prescription, biologic variations in the tooth structure, the maxillary/mandibular relationships, tissue rebound, the mechanical deficiencies of the edgewise orthodontic appliances[37], and the variation in different biomechanical principles should be taken into account.[38]

Further investigation is required to identify the most reliable technique for bracket placement and, therefore, allow the optimum performance to be achieved from a preadjusted bracket system.[17] The future construction of custom made brackets, adjusted to individual facial contour differences, will also require information regarding the optimal tooth position ahead, including compensations necessary for variations in facial skeletal patterns.

These results are preliminary, and obtained from a small sample. A more complete study with a larger sample is necessary to evaluate the effect of vertical bracket displacement more precisely. In circumstances in which the bracket has to be positioned more gingivally, it would be useful to provide the chart of torque alteration of each tooth referred to in this study with the respective bracket prescriptions.

CONCLUSIONS

The purpose of this study was to evaluate the effect of variations in the vertical position of brackets on the crown inclination in Korean patients with normal occlusion.

The sample was composed of 10 Korean normal occlusion subjects. The dental casts of the subjects were scanned three-dimensionally by a laser scanner and measured with a computer program. At first, the occlusal plane and bracket plane were determined. The tooth plane was then constructed to measure the crown inclination on the bracket plane of each tooth. From a practical standpoint, information was obtained on the extent to which the torque of a tooth would be changed if a bracket position was to be moved vertically (in ± 0.5 mm, ± 1.0 mm, ± 1.5 mm) from its ideal position.

A one way analysis of the variance(ANOVA) was used to compare each group of differing vertical distances from the bracket plane on each specific tooth. Duncan's multiple comparison test was then performed.

Statistically significant differences in crown inclination among the groups of differing vertical distances for the upper central incisor, upper lateral incisor, upper canine, upper first and second molars, lower first and second premolars, and lower first and second molars(p<0.05) were recorded.

On the upper anterior teeth, upper molars, lower premolars and lower molars, the resultant torque values due to the vertical displacement of a bracket were differed depending on the direction of the displacement, as either occlusal or gingival.

This study implies that the torque of these teeth should be handled carefully in orthodontic treatment. In cases in which the bracket has to be positioned more gingivally or occlusally arising in various circumstances, it would be useful to provide the chart of torque alteration of each tooth referred to in this study with the respective bracket prescriptions.

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국문초록

브라켓의 수직적 위치변동에 따른 치관경사도변화에 관한 연구

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정교한 교합을 달성하기 위해서는 브라켓을 정확하게 위치시키는 것이 필수적이다. 그러나, 많은 원인에 의해 브라켓의 위치가 변할 수 있다.

본 연구는 브라켓의 수직적 위치에 변화가 있을 때 이것이 치관경사도에 미치는 영향을 연구하고자 함이다.

연구대상으로는 서울대학교 치과대학 교정학교실의 정상교합자 표본 중 상태가 양호한 10명(남자 6명, 여자 4명, 평균 연령 22.3세)을 대상으로 하였으며, 이들의 치아모형을 laser scanner를 이용, 3차원적으로 스캔을 시행하였고, 컴퓨터 프로그램 상에서 스캔된 치아모형에 대한 계측을 실시하였다. 각 모형에 대하여 Bracket plane을 설정하였고, 각 치아에서 Bracket plane에 수직이며 치아의 장축을 지나는 Tooth plane을 순협면에서 결정한 뒤 Bracket plane 상에서의 치관경사도를 계측하였다. 이로부터 Bracket plane을 상하로 0.5 mm, 1.0 mm, 1.5 mm 변위시켰을 때의 치관경사도를 계측하였다.

각 계측 항목에 대해 일원분산분석(oneway ANOVA)과 Duncan's multiple comparison test를 시행하였다.

이상의 연구로부터 다음과 같은 결과를 얻었다.

1. 상악중절치, 측절치, 견치, 대구치와 하악소구치, 대구치에 있어서 브라켓의 수직적 위치가 변화함에 따라 치관경사도가 통계적으로 유의성있게 차이있는 것으로 나타났다($p<0.05$).
2. 상악전치와 대구치, 하악소구치와 대구치에서는 기준평면으로부터 수직적으로 같은 양만큼 변위되었다 할지라도 보다 교합면쪽에 위치하는지, 보다 치은쪽에 위치하는지에 따라 치관경사도의 변화량이 다르게 나타났다.
3. 브라켓의 수직적 위치변화가 있을 경우 상악전치부와 대구치, 하악구치부, 이 중 특히 하악구치부의 치관경사도는 임상적으로 영향을 받게 되므로 브라켓을 위치시킬 때 주의를 요해야 할 것으로 생각된다.

주요 단어 : 치관경사도, 토오크, 3차원 스캐너, 정상교합