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Original Article

Evaluation of Bracket Positioning; A Customized System Versus the Conventional Method

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Main Points

- Bracket placement varies in vertical position on the clinical crown depending on the method used, with differences observed among the Insignia system, the Kalange method, and Andrews' bracket-positioning approach.
- In both the Insignia system and the Kalange method, brackets tend to be positioned more incisally or occlusally relative to the facial axis point.
- In the Insignia system and Kalange method, anterior brackets are positioned more incisally than posterior brackets.

ABSTRACT

Objective: To evaluate the positioning of brackets in customized and conventional bonding methods in accordance with Andrews' approach to bracket placement.

Methods: Twenty-six patients were enrolled; 11 were treated with the Insignia system and 15 with Kalange's method. Crown length was measured on a digital diagnostic model and the facial axis (FA) point was calculated. After leveling and alignment, a new digital model was created, and the bracket position was measured along the vertical axis. The distance between the bracket position and the FA point was calculated, and the deviation was determined according to Andrews' method. Teeth with significant deviation (TSD), i.e., >0.5 mm, were identified. Frequencies and percentages of TSD were calculated.

Results: The TSD percentage was 56.65% in the Insignia group and 69.5% in the modified Kalange group; the difference between groups was significant (p=0.003). The anterior and posterior regions differed significantly within groups: in the Insignia group, this difference was observed in the maxilla (p=0.002), whereas in the modified Kalange group it was observed in both the mandible and maxilla (P < 0.001). In both groups, the anterior TSD percentage was higher than the posterior TSD percentage in both the maxilla and the mandible. The deviation was predominantly occlusal or incisal: Insignia group, 86.9%; modified Kalange group, 97.6%.

Conclusion: In the Insignia system and Kalange's method, brackets are positioned more incisally/occlusally relative to Andrews' FA point. In both methods, anterior brackets are positioned more incisally than posterior brackets.

Keywords: Bracket placement, Insignia, Kalange, Andrews

INTRODUCTION

The straight-wire appliance (SWA) is widely used in orthodontic treatment. In this technique, accurate bracket placement is the most crucial stage of treatment. If the bracket is not ideally placed, unplanned tooth movement occurs, leading to changes in the tip, torque, and rotation of the tooth. To rectify this error, archwire bending or bracket repositioning is usually necessary to achieve the desired outcome.[1,2]

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As a pioneer of the SWA technique, Andrews introduced two concepts related to bracket placement: the facial axis of the clinical crown (FACC) and the facial axis (FA) point. The FACC is defined as the long axis passing through the center of the facial surface of the clinical crown. The FA point is the midpoint of the FACC. Andrews identified the FA point as the optimal location for bracket placement and emphasized that the bracket's wings should be parallel to the FACC.[3-5]

Kalange introduced an indirect bonding method in which brackets were positioned on the teeth using millimetric measurements. He traced vertical lines indicating the long axes of the teeth and horizontal lines passing through the mesial and distal marginal edges of the posterior teeth on the study models. Brackets were positioned with reference to these lines.[6,7]

With the advancement of digital technologies, human errors in dentistry have been minimized. The Insignia™ Advantage System (Ormco, Brea, CA, USA), which incorporates self-ligating appliances and customized bracket slots, is among these developments. Using computer-assisted technology, a virtual design of the final alignment and occlusion can be obtained through reverse-engineered archwires and brackets. Bracket bases are standard; bracket slots are custom-produced to achieve the desired tooth movement through archwire progression, resulting in a straight finishing archwire. In the Insignia™ Advantage System, bracket-positioning points are determined virtually, and customized brackets are bonded using indirect-bonding transfer jigs.[8-13]

In the present study, the null hypothesis was that there would be no significant difference in the vertical bracket position on the clinical crown among the Insignia system, Kalange's method, and Andrews' bracket-positioning approach. The aim of the present study was to evaluate bracket positioning using customized and conventional bonding methods according to Andrews' approach to bracket placement.

METHODS

Ethical approval was obtained from the Ethics Committee of Ondokuz Mayıs University Medical Faculty (approval number: B.30.2.ODM.020.08/496, date: 14.06.2019). Since no study with the same design as the present one was found in the literature, the sample size was calculated based on the study by Koo et al.,[14] which was deemed most similar in design. With 80% power, a two-tailed significance level of 0.05, and transfer error means±standard deviations of 0.41±0.23 mm and 0.18±0.12 mm for the first and second groups, respectively, the minimum sample size calculated for the present study to detect a significant difference was 26 patients (13 per group). To compansate for possible dropout, the sample size was increased to 15 patients per group.

A total of 30 patients who presented to the Department of Orthodontics, Ondokuz Mayıs University Faculty of Dentistry were enrolled in the study. Written informed consent was obtained from all patients or their parents. The inclusion criteria were: (1) permanent dentition from the first molar to the first molar; and (2) Little's Irregularity Index[15] ≤3 mm (minimal crowding). The exclusion criteria were: (1) systemic diseases; (2) dentition that precludes ideal bracket placement; (3) dentition with shape or size anomalies, attrition, or abrasion; and (4) unhealthy gingival tissue. Based on the inclusion and exclusion criteria, the patients were allocated to two groups to undergo nonextraction fixed orthodontic treatment. The Insignia™ Advantage system was used in Group 1, and Kalange's method was used in Group 2.

Group 1 (Insignia)

- For each patient, an alginate impression (Zetalgin, Zhermack SpA, Badia Polesine, Italy) and a type C-polysiloxane impression (Zetaplus, Zhermack SpA) were taken. Two plaster models were obtained: a diagnostic model [T(0)] from the alginate impression and a treatment model from the C-polysiloxane impression.
- The treatment model was sent to the manufacturer (Ormco).
- Model scanning, digital modeling, and the initial setup were performed by a technician at Ormco.
- An orthodontist adjusted the ideal treatment plan using Insignia's Approver software (a trademark of Ormco).
- Custom-fabricated custom self-ligating brackets (Damon Q, Ormco), archwires, and transfer jigs were used.
- The orthodontist bonded the brackets using transfer jigs.

Group 2 (Modified Kalange)

- Two alginate impressions (Zetalgin, Zhermack SpA, Badia Polesine, Italy) were taken from each patient.
- Plaster models were obtained from these impressions: a diagnostic model [T(0)] and a treatment model.
- The treatment model was sent to a private orthodontic laboratory in Türkiye (Digital Ortodonti Laboratuvarı).
- Model scanning was performed using a 3D scanner (3Shape R-700 Desktop Orthodontic Scanner; 3Shape, Copenhagen, Denmark).
- Virtual brackets (Damon Q, Ormco) were placed on the teeth by a technician using Onyxceph³™ Dental Imaging Software (Chemnitz, Germany) in accordance with Kalange's method.
- The orthodontist verified the accuracy of the bracket placement and performed indirect bonding using the transfer tray fabricated from this setup. A virtual model with brackets was 3D-printed using a methacrylate-based resin (IMPRIMO® LC Model, Scheu-dental GmbH, Iserlohn, Germany).
- A transfer tray was fabricated from a double-layer, vacuum-formed viscoelastic plate (INDIVIDUA® Foil, Scheu-Dental GmbH) using the virtual model with brackets.

- The brackets were placed in the transfer tray.
- And the orthodontist performed indirect bonding using this tray.

All patients in both groups were treated by the same orthodontist. Four patients in the Insignia™ group who failed to attend scheduled appointments regularly were excluded from the study. In cases of bracket debonding, the teeth involved were excluded from the analysis.

In both groups, the leveling and aligning stages were completed with a 0.019″×0.025″ stainless-steel archwire, which remained in place for at least 1 month. After this period, the archwire was removed, an alginate impression was taken, and a plaster model with brackets, T(1), was obtained.

Measurement Technique

The T(0) and T(1) models were digitized using the 3D scanner (3Shape R700, 3Shape, Copenhagen, Denmark). Bracket positions were evaluated using the Ortho Analyzer software (3Shape) according to the FA point defined by Andrews.

Step 1: The crown lengths of anterior and premolar teeth were measured on virtual T(0) models as the linear distance between the gingival zenith and the incisal edge or cusp tip, parallel to the long axis of each tooth (Figure 1).

Step 2: On the virtual T(1) models, horizontal planes passing through the mesial and distal contact points of the premolars were defined on virtual T(1) models (Figure 2).

Step 3: For the anterior teeth, horizontal planes passing through the centers of the bracket slots were created for the anterior teeth on virtual T(1) models (Figure 3).

***All planes shown in Figure 2 and Figure 3 were created perpendicular to the teeth.

Step 4: The value a was calculated by dividing each crown length by two, and the ideal bracket positioning points were determined according to Andrews (Figure 1). For the anterior teeth, the value b was measured as the distance from the horizontal plane to the incisal edge or cusp tip (Figure 3). For the posterior teeth, value b was calculated by summing the distance from the bracket center and from the cusp tips to the horizontal plane, and then summing these distances (Figure 4). Finally, the value c was obtained by subtracting value a from value b to quantify the deviation from the ideal bracket position.

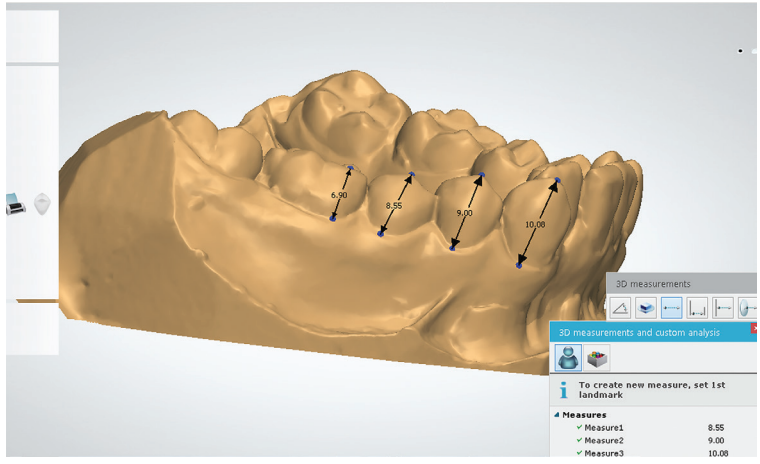

Figure 1. Measurement of the crown length.

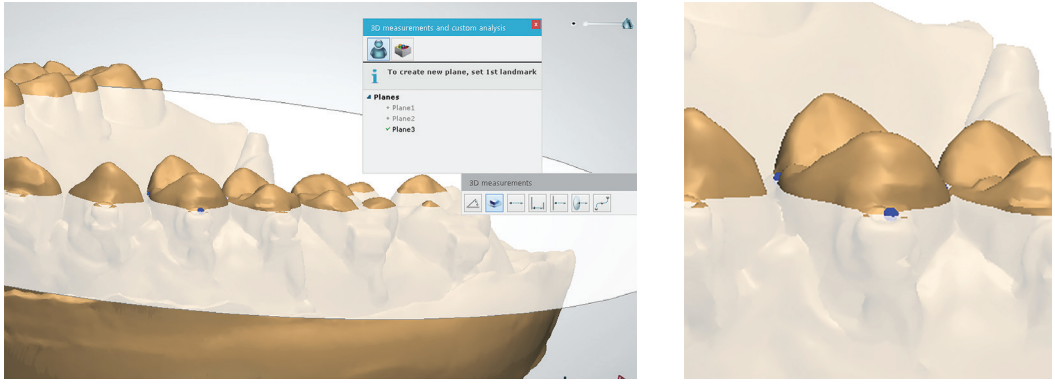

Figure 2. A horizontal plane passing through the mesial and distal contact points of the premolar tooth.

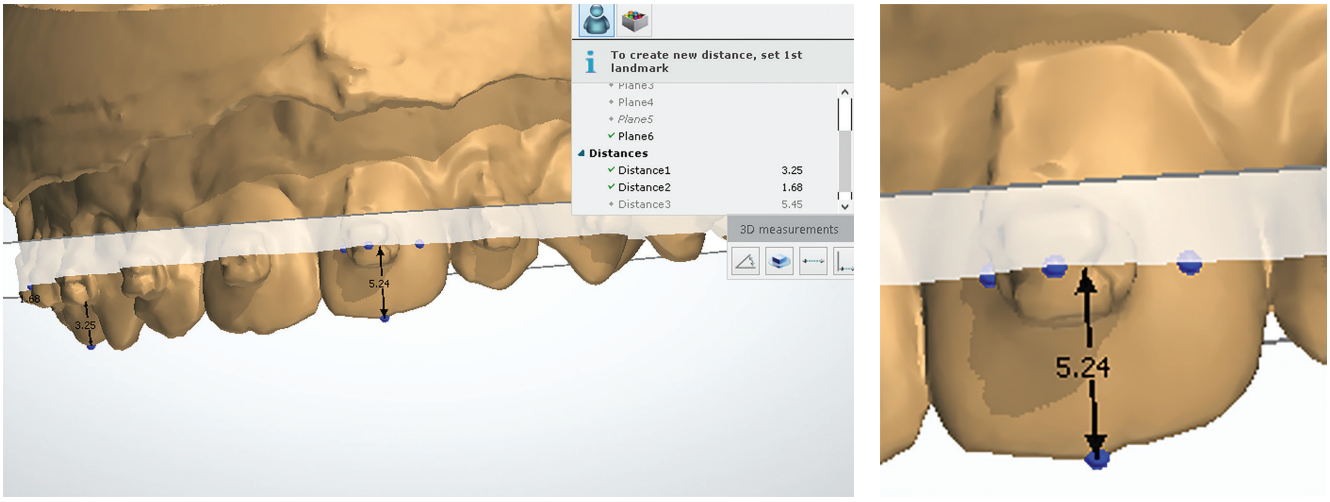

Figure 3. A horizontal plane passing through the center of the slot of the central bracket.

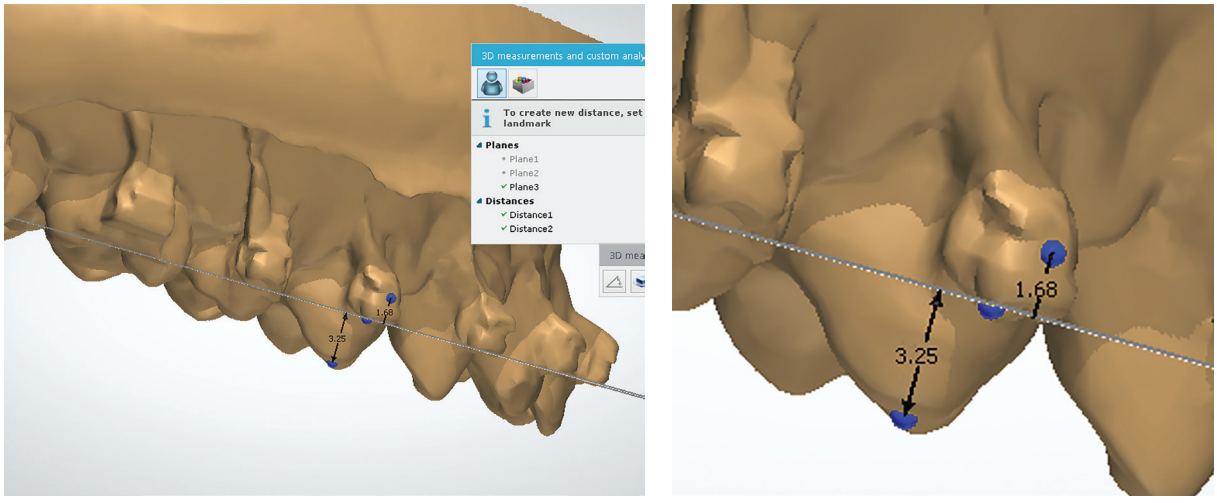

Figure 4. The distances from the center of the bracket and the tip of the cusp to the horizontal plane.

Assessment of Bracket Positions

The deviation of each bracket from its ideal position was calculated using the following formula:

(value b) - (value a) = (value c)

If value c=0, the bracket was positioned ideally.

If value c<0, the bracket was positioned gingivally.

If value c>0, the bracket is positioned incisally or occlusally.

According to Andrews, an acceptable error limit for bracket positioning accuracy is 0.5 mm or less.[16] Therefore, the the deviations were classified as follows:

If |value c| >0.5 mm, the deviation was considered significant.

If |value c| ≤0.5 mm, the deviation was considered not significant.

Statistical Analysis

SPSS 26.0 for Windows 64-bit software (SPSS, Chicago, IL, USA) was used for the statistical analyses. The Kolmogorov-Smirnov and Shapiro-Wilk tests were performed to assess whether continuous variables followed a normal distribution, and skewness and kurtosis values were examined. Variables with a p-value ≥0.05 in the normality tests were considered to follow a normal distribution. The consistency between observers was confirmed using Pearson's correlation coefficient calculated from bivariate analysis. Categorical variables were described as frequencies and percentages and compared using the chi-squared test. Mean differences between independent groups were analyzed using Student's t-test. Power analysis was performed using G*Power 3.1.

RESULTS

The power of the present study was calculated to be 86% for the overall measurement at the 95% confidence level. To determine the intraclass correlation, seven models were selected and measurements were repeated by a second practitioner. The correlation coefficients ranged from 0.90 to 1.00, indicating excellent agreement between observers.

Table 1 presents the demographic data for the modified Kalange and Insignia groups. The Insignia group consisted of 11 patients (216 teeth) whereas the modified Kalange group included 15 patients (295 teeth). The study included 7 female participants in the Insignia group and 12 female participants in the modified Kalange group. The mean age was 15.5 years (standard deviation 1.4) in the modified Kalange group and 15.2 years (standard deviation 2.2) in the Insignia group.

Table 2 shows the comparison of crown lengths across groups, with no significant differences observed for any tooth. Table 3 presents the percentages of teeth with significant deviation (TSD) for each group and the p-values. A significant difference between the groups was observed for all lower anterior teeth [p<0.001 (L3), p=0.003 (L2), and p=0.001 (L1)]. The overall percentage of TSD was 56.6% and 69.5% in the Insignia and modified Kalange groups, respectively. The difference between the groups was significant (p=0.003).

Table 4 presents the percentage of TSD by region. In the Insignia group, the percentage of TSD was 66.2% for the anterior maxilla and 34.1% for the posterior maxilla, indicating a significant difference between these regions (p=0.002). The percentage of TSD was 66.2% in the anterior mandible and 50.0% in the posterior mandible, with no significant differences observed between these regions. In the modified Kalange group, the percentage of TSD was 78.9% in the anterior maxilla and 15% in the posterior maxilla, indicating a significant difference between these regions (p<0.001). In the mandible, TSD occurred in 100% of the anterior region and 64.3% of the posterior region, again showing a significant difference (p<0.001).

Tables 5 and 6 show the directions of deviation. In the Insignia group, all anterior TSDs exhibited incisal deviation. Among the maxillary posterior TSDs, 86.7% deviated gingivally. For the mandibular posterior TSD, 85.7% deviated in the occlusal direction. In the modified Kalange group, all anterior TSDs also showed incisal deviation. Moreover, among the maxillary posterior TSDs, 66.7% showed occlusal deviation, while 94.4% of the mandibular posterior TSDs showed occlusal deviation. Overall, 86.9% of TSDs in the Insignia group and 97.6% in the modified Kalange group deviated occlusally or incisally.

Figure 5 illustrates the percentage of TDS alongside the direction of deviation for each group.

Table 1. Demographic data for the Insignia and Modified Kalange groups

	Insignia	Modified Kalange	Overall
Number of patients (n, %)	11 (42.3%)	15 (57.7%)	26 (100%)
Female (n, %)	7 (63.6%)	12 (80%)	19 (73.1%)
Age (mean±SD)	15.55±1.44	15.27±2.25	15.38±1.92
Number of teeth (n, %)	216 (42.3%)	295 (57.7%)	511

SD, standard deviation.

Table 2. Comparison of crown lengths between the groups

	Insignia		Modified Kalange		
Tooth	**N**	**Mean±SD (mm)**	**N**	**Mean±SD (mm)**	**p-value**
U5	22	6.61±0.69	30	6.71±0.65	0.595
U4	22	7.38±0.73	30	7.5±0.57	0.526
U3	22	9.63±1.33	30	9.68±0.66	0.869
U2	22	8.49±0.95	30	8.37±0.66	0.62
U1	21	10.16±1.18	30	10.36±0.81	0.470
L5	21	7.21±0.76	27	7.31±0.5	0.586
L4	21	8.2±0.99	29	8.31±0.43	0.596
L3	22	10.03±1.46	30	10±0.58	0.862
L2	21	9.04±1.12	30	9.23±0.43	0.431
L1	22	8.75±0.8	29	9.04±0.5	0.128

p-values calculated by Student's t-test, significance level, p≤0.05.
N, total number of teeth; SD, standard deviation.

Table 3. Comparison between the percentages of teeth with significant deviation for each group

	Insignia			Modified Kalange			
Tooth	N	n	n (%)	N	n	n (%)	p-value
U5	22	7	31.8	30	4	13.3	0.169
U4	22	8	36.4	30	5	16.7	0.195
U3	22	13	59.5	30	21	70	0.602
U2	22	12	54.5	30	23	76.7	0.167
U1	21	18	85.7	30	27	90	0.680
L5	21	9	42.9	27	17	63	0.274
L4	21	12	57.1	29	19	65.5	0.759
L3	22	13	59.1	30	30	100	<0.00*
L2	21	15	71.4	30	30	100	0.003*
L1	22	15	68.2	29	29	100	0.001*
Overall	216	122	56.5	295	205	69.5	0.003*

*Statistically significant difference, significance level, p≤0.05.
N, total number of teeth; n, number of teeth with significant deviation; p-values calculated by the chi-squared test.

Table 4. Comparison between the percentages of teeth with significant deviation by region

	Maxillary anterior region			Maxillary posterior region			
	N	n	n (%)	N	n	n (%)	p
Insignia	65	43	66.2	44	15	34.1	0.002*
Modified Kalange	90	71	78.9	60	9	15.0	<0.00*
	Mandibular anterior region			Mandibular posterior region			
	N	n	n (%)	N	n	n (%)	p
Insignia	65	43	66.2	42	21	50.0	0.144
Modified Kalange	89	89	100	56	36	64.3	<0.00*

*Statistically significant difference, significance level, p≤0.05.
N, total number of teeth; n, number of teeth with significant deviation; p-values calculated by the chi-squared test.

Table 5. Number/percentage of teeth with significant deviation positioned occlusally/incisally or gingivally

	Insignia					Modified Kalange				
		O/I		G			O/I		G	
Tooth	N	n	n (%)	n	n (%)	N	n	n (%)	n	n (%)
U5	7	1	14.3	6	85.7	4	2	50	2	50
U4	8	1	12.5	7	87.5	5	4	80	1	20
U3	13	13	100	0	0	21	21	100	0	0
U2	12	12	100	0	0	23	23	100	0	0
U1	18	18	100	0	0	27	27	100	0	0
L5	9	9	100	0	0	17	16	94.1	1	5.9
L4	12	9	75	3	25	19	18	94.7	1	5.3
L3	13	13	100	0	0	30	13	100	0	0
L2	15	15	100	0	0	30	15	100	0	0
L1	15	15	100	0	0	29	15	100	0	0
Overall	122	106	86.9	16	13.1	205	200	97.6	5	2.4

N, total number of teeth with significant deviation; n, number of teeth with significant deviation; O, occlusally; I, incisally; G, gingivally.

DISCUSSION

Accurate bracket placement is a crucial part of treatment using the SWA technique. To achieve the desired tooth movement, ideal bracket positioning is required.[17] Andrews emphasized that the bracket should be positioned at the midpoint of the clinical crown and on the long axis of the tooth to achieve accurate expression of the bracket prescription. This study aimed to evaluate the bracket positions obtained by two different methods, using this concept as a reference. The findings revealed significant differences between the groups in both overall and regional deviations; therefore, the null hypothesis was rejected.

The Insignia™ Advantage system positions brackets digitally on a 3D model. This system aims to control tooth positions and arch form in 3D, ensure occlusal contacts, and achieve an excellent smile design.[8,18] The system uses the reverse-engineering principle and determines the positions and occlusal relationships of the teeth at the end of the treatment using 3D simulation. Bracket placement is performed according to this virtual setup.

Table 6. Number/percentage of teeth with significant deviation positioned occlusally/incisally or gingivally by region

	Insignia					Modified Kalange				
		O/I		G			O/I		G	
Region	N	n	n (%)	n	n (%)	N	n	n (%)	n	n (%)
Maxillary anterior	43	43	100	0	0	71	71	100	0	0
Maxillary posterior	15	2	13.3	13	86.7	9	6	66.7	3	33.3
Mandibular anterior	43	43	100	0	0	89	89	100	0	0
Mandibular posterior	21	18	85.7	3	14.3	36	34	94.4	2	5.6

N, total number of teeth; n, number of teeth with significant deviation; O, occlusally; I, incisally; G, gingivally.

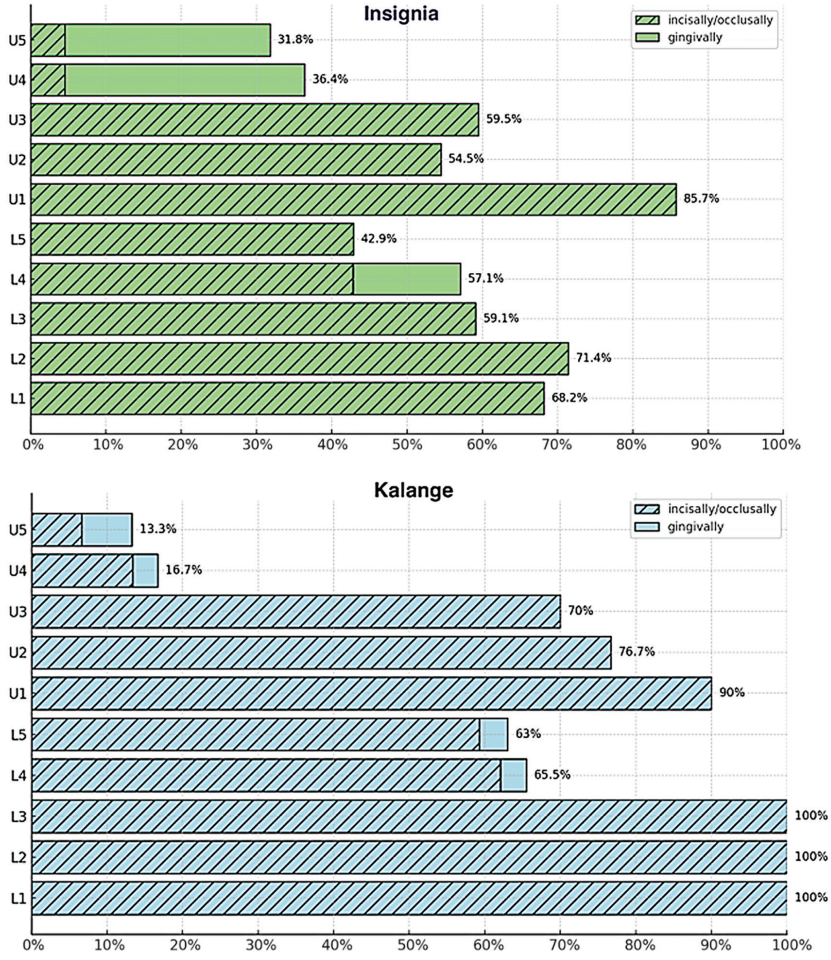

Figure 5. Percentages of teeth with significant deviation and directions of deviation.

In Kalange's method, a conventional indirect bonding technique, the brackets are placed on vertical lines indicating the long axes of the teeth and on horizontal lines parallel to the mesial and distal marginal ridges of the posterior teeth. These lines are customized for each patient and serve as a guide for bracket placement. The method aims to achieve aesthetic harmony, fulfill the treatment objectives, and ensure proper function with leveled marginal ridges, canine guidance, and incisor guidance.[7] In the present study, Kalange's technique was modified so that brackets were positioned digitally on 3D virtual models rather than manually on plaster casts. This modification allowed both the Insignia and the modified Kalange methods to be implemented within a standardized digital workflow. Consequently, bracket positioning was conducted in a computer environment for both Kalange's method and the Insignia system, achieving standardization between the two methodologies.

Treatment models in the Insignia and modified Kalange groups were produced using two impression materials: polyvinyl siloxane and alginate. Previous studies by Petrović et al.[19] and Bud et al.[20] have demonstrated that plaster models produced from silicone impressions are more accurate than plaster models produced from alginate. However, Torassian et al.[21] reported that plaster models produced from a traditional color-change alginate and stored for up to one week exhibited dimensional deviations of less than 0.5 mm, which are clinically insignificant. Similarly, Vogel et al.[22] concluded that alginate-derived plaster models are reliable for orthodontic use. In the present study, although the impression materials differed between the two groups, the discrepancy remained within acceptable limits and was considered negligible in both groups.

The effect of transfer trays on bracket positioning in indirect bonding methods has been investigated in previous studies. Gündoğ et al.,[23] Schmid et al.,[24] and Niu et al.[25] reported clinical acceptability rates for double vacuum-formed trays of 95%, 94%, and 91.4%, respectively. The mean deviations were 0.23 mm, 0.10 mm, and 0.23 mm; the first and third values (0.23 mm) include molars, where most deviations occurred. Gündoğ et al.[23] and Niu et al.[25] found that 3D-printed transfer trays demonstrated higher accuracy than vacuum-formed trays; however, the data obtained from both methods were clinically comparable. Furthermore, in a study comparing CAD-CAM systems, Albertini et al.[26] reported that the mean vertical deviation of the Insignia system was 0.28 mm. Dr. Leon Verhagen stated that the Insignia system achieved a bracket-transfer accuracy of 98% based on more than 105 Insignia SL cases.[27] In the present study, although the bracket transfer methods differed between the two groups, bracket accuracy was judged-based on previous research-to be within clinically acceptable limits and was therefore considered unlikely to have introduced bias into the outcomes.

In the Insignia group, the percentage of TSD was over 50% for all teeth except U4s, U5s, and L5s (which showed deviations of 36.4%, 31.8%, and 42.8%, respectively), resulting in an overall deviation ratio of 56.5%. This difference may be attributed to the approach used for bracket placement. While Andrews conventionally places brackets directly on the patient in a clinical setting based on clinical crown length, the Insignia system, as claimed by the manufacturer, evaluates all morphological characteristics of each tooth individually for bracket placement. It is claimed that the system takes into account arch form and pretreatment in-out, tip, and torque values, with the stated aim of achieving a more precise treatment plan and more accurate bracket placement.[28]

Kalangeon the other hand, argues that although Andrews' FA point concept provides a solid theoretical foundation, it presents several limitations in certain clinical situations. Kalange indicates that, in patients with large anterior and small posterior teeth, extrusion of the anterior teeth and intrusion of the posterior teeth would be expected, whereas the opposite pattern would occur in patients with small anterior and large posterior teeth. When both methods are compared, the Kalange approach results in bracket placement that is more incisal/occlusal on large teeth and more gingival on small teeth compared to the FA point. Kalange suggests that this individualized bracket placement strategy may help prevent clinical complications associated with the Andrews method.[7]

German et al.[29] synthesized data from studies on anterior crown length conducted by Chu[30], Chu and Okubo[31] and presented mean values in a summary chart. Consistent with these findings, Volchansky et al.[32] comprehensively reported the clinical crown lengths of the maxillary and mandibular teeth. The measurements in our study were consistent with those reported in previous research. Moreover, no significant differences were found in crown length values between the modified Kalange and Insignia groups. In the present study, except for U4 and U5 (13.3% and 16.7%, respectively), the percentage of TSD exceeded 50% for all teeth, resulting in an overall percentage of 69.5% in the modified Kalange group. Considering the directions of bracket deviations, 97.6% of TSD were oriented in the incisal/occlusal direction. Our findings suggest that the deviation observed in the Kalange group is not due to individual variation in crown length but is directly attributable to Kalange's methodology.

In Kalange's method, posterior brackets are positioned 2 mm gingival to the horizontal line passing through the marginal ridges of the teeth. For anterior brackets, the reference point is the distance from the bracket position on the first premolar to the cusp tip of the same tooth. Given that the present study included teeth with average crown lengths, these findings indicate that the 2-mm reference value used in Kalange's method is insufficient for such teeth according to Andrews' concept. This results in the brackets being positioned incisal to the midpoint of the clinical crown.

In our study, the anterior and posterior regions were also compared. A significant difference in the number of TSDs between the anterior and posterior regions of the maxilla was observed in the Insignia group (p=0.002). In the modified

Kalange group, significant differences were observed between the anterior and posterior regions of both the mandible and the maxilla ($p<0.001$ for both regions). In both groups, deviation rates in the anterior regions of the maxilla and mandible were higher than those in the posterior regions. Examination of bracket direction showed that all anterior brackets in both groups were positioned incisally. This positioning of the brackets may result in intrusion of anterior teeth and, due to their more gingival placement, extrusion of posterior teeth. In both methods, these tooth movements may facilitate the flattening of the curve of spee and enable easier interdigitation, thereby reducing the need for a finishing stage in orthodontic treatment.

In the Insignia group, as mentioned above, in addition to differences between the anterior and posterior regions of the maxilla, the deviation ratio of U1 was higher (85.7%) than that of U2 and U3 (54.5% and 59.5%, respectively). It may be considered that both of these factors lead to an increased compensating curve and a flat smile arc characterized by a maxillary incisal arc line that is flatter than the curvature of the lower lip on smile.[33-35] That similar results were observed in the modified Kalange group-where bracket positions are determined using the incisal edge or cusp tip as reference points and millimetric adjustments are made to ensure esthetic alignment-calls into question the Andrews approach. These results should be corroborated by comparative studies that evaluate the impact of bracket-positioning methods on the smile arc at treatment completion.

In the SWA technique, bracket position is the primary factor affecting the tip, torque, and rotation of the tooth. Variations in bracket placement methods can significantly affect treatment outcomes by causing differences in tooth movement. Although digital treatment planning within the Insignia system facilitates accurate results, the potential for errors in bracket positioning remains a concern.[12] In addition, estimation of the midpoint of the clinical crown using Andrews' method may be subject to human error. Conducting two-dimensional measurements within a three-dimensional environment may compromise standardization in Kalange's method. Our study focuses on determining differences in bracket position among the methods mentioned, using measurements. In light of the results obtained, future studies evaluating the impact of differences in bracket placement on the effectiveness of orthodontic treatment will complement the present research.

Study Limitations

Certain limitations inherent to the study design should be acknowledged. Although all patients were enrolled within the same time period and both the methodology and the examiner were consistent, prospective randomization was not implemented. Although any resulting bias is likely negligible, its potential influence on the outcomes cannot be entirely excluded.

In order to enhance the statistical power of our study, the initial sample size was expanded. However, several patients in the Insignia group were excluded due to follow-up issues, which reduced the final sample size. This limitation should be considered within the scope of the study.

CONCLUSION

In both the Insignia system and Kalange's method, brackets were positioned more incisally or more occlusally relative to Andrews' FA point. In both systems, anterior brackets were positioned more incisally than posterior brackets.

Ethics

Ethics Committee Approval: Ethical approval was obtained from the Ethics Committee of Ondokuz Mayıs University Medical Faculty (approval number: B.30.2.ODM.020.08/496, date: 14.06.2019).

Informed Consent: Informed consent was obtained from all participants or their legal guardians after all explanations and clarifications regarding the trial had been provided.

Footnotes

Author Contributions: Surgical and Medical Practices - K.S., M.Ö.; Concept - K.S., M.Ö.; Design - K.S., M.Ö.; Data Collection and/or Processing - K.S.; Analysis and/or Interpretation - K.S., M.Ö.; Literature Search - K.S.; Writing - K.S.

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