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Original research article

Comparison of the initial levelling efficiency of two different self-ligating brackets

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Abstract

Aim: This study aims to evaluate the initial alignment effectiveness of two different passive self-ligating brackets (SLBs) and to compare the differences in arch widths.

Materials and Methods: This study included patients treated with SLBs, without skeletal discrepancy, with Little's irregularity index (LII) greater than 3 mm in both arches, and with undamaged plaster models available at the beginning of treatment (T0), 10th (T1) and 20th (T2) weeks of treatment. Group 1 (Damon) consisted of 17 patients (mean age=14.5 years) and Group 2 (SmartClip) consisted of 18 patients (mean age=13.6 years). The analog dental casts were transferred to digital models by scanning. Maxillary and mandibular intercanine, intermolar widths, and LII were measured with MeshLab software. Wilcoxon signed-rank and Mann-Whitney U tests were used for statistical evaluation ($p<0.05$).

Results: There was no significant difference between the groups for the mean LII in T0 (maxillary LII, Group 1= 6.59 mm; Group 2= 6.32 mm; mandibular LII, Group 1= 5.95 mm, Group 2= 5.73mm). The rate of decrease in the LII between T0-T2 and between T1-T2 was found to be significantly higher for Group 1 in the mandible, but there was no significant difference between T0-T1 (P= 0.031, P= 0.042, P= 0.113). Also, there was no significant difference in the rate of decrease in the LIIs between the groups in the maxilla. When changes in intermolar and intercanine widths were compared according to the follow-up times, no significant difference was found for the treatment groups.

Conclusion: Both SLBs groups were effective in reducing the crowding in the maxillary arch. The increases in intercanine and intermolar widths were found to be similar for both groups. Group 1 was found to be better in the speed of the resolution of the crowding only in the lower incisor region.

Keywords: Orthodontic appliances; orthodontic brackets; orthodontics.

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[Abstract in Turkish is at the end of the manuscript]

Introduction

Self-ligating brackets (SLBs) have gained popularity in recent years and they are claimed to have many advantages over conventional brackets. The main advantage of SLBs is the reduced levels of friction.[1–4] There are many *in vitro* studies in the literature showing that SLBs create less friction than conventional brackets.[1,2,5,6] Therefore, it has been emphasized that tooth movement can be achieved with less force.[7] Secure and faster archwire-bracket ligation[8], reduced chair-time[9,10] and increased ergonomics[10], shortened treatment time[10], better-sliding mechanics and anchorage control[11], less patient discomfort[12] and improved oral hygiene[5] are counted among the other advantages of self-ligating brackets. However, there are also disadvantages such as the possibility

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of valve breakage, high cost, and increased occlusal interferences.[13]

In vitro studies have shown that passive self-ligating brackets provide a greater reduction in friction forces for round wires than conventional brackets.[4,14] Tecco *et al.*[14] observed that round wires had lower friction values in the active SLBs and the rectangular wires had lower friction values in the passive SLBs. However, it has been shown that both SLBs had lower friction values than conventional brackets in all archwire materials and diameters.[14] A recent finite element analysis concluded that SLBs have less friction than conventional brackets during the space closure stage.[15] Despite claims regarding the clinical superiority of SLBs, a systematic review found that the existing evidence does not support that SLBs systems permit faster space closure than conventional brackets.[13]

SLBs are divided into two groups as active and passive according to their closing mechanisms. Active SLBs have active clips that press the archwire into the bracket slot; however, passive SLBs act like a “tube” in the closed position.[16] Passive SLBs display different structural mechanisms and do not apply forces to the archwire. Damon Q bracket (SDS Ormco, Glendora, CA, USA) includes a sliding door as a facial barrier but SmartClip-SL3 bracket (3M Unitek, CA, USA) has a unique clip structure without a facial barrier.

Conventional brackets and SLBs and active and passive SLBs have been compared in many studies.[17–25] However, passive SLBs which differ in design have not been compared for their treatment efficiency. To that end, the aim of the present study is to evaluate the initial levelling efficiency of two different passive SLBs in the resolution of anterior crowding and to compare the changes in intermolar and intercanine widths at 10-week intervals using orthodontic digital model analysis. The null hypothesis of the present study is that no differences exist in the levelling efficiency of the two different SLBs.

Materials and Methods

This retrospective study was approved by Başkent University Institutional Review Board (Project number: D-KA 17/0624-11.2017). Written informed consent was obtained from patients at the beginning of their treatment as a standard procedure. Treatment records of the patients were evaluated according to the following inclusion criteria: (1) Patients who were treated with self-ligating appliances, (2) Non-extraction orthodontic treatment, (3) Lower-upper brackets placed in the same session, (4) Eruption of all permanent teeth except 3rd molars, (5) Normal growth pattern with no skeletal discrepancy, (6) No previous orthodontic treatment, (7) No supernumerary or congenitally missing teeth, (8) No maxillary expansion or functional treatment, (9) No genetic or systemic problems, (10) Little’s irregularity index greater than 3 mm on both arches.

After the first selection, the model archive of our university was investigated and the patients who had undamaged plaster models at the beginning, 10th week, and 20th week of the treatment were included in the study. Thirty-five patients met these inclusion criteria, and the demographics of the patients are shown in Table 1.

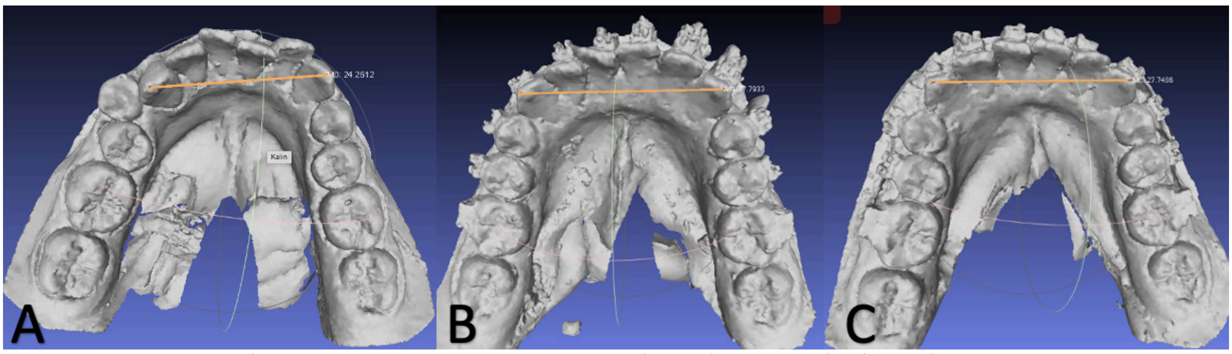

Figure 1. *Digital measurement of mandibular intercanine width **A.** Pretreatment **B.** 10th week of the treatment **C.** 20th week of the treatment.*

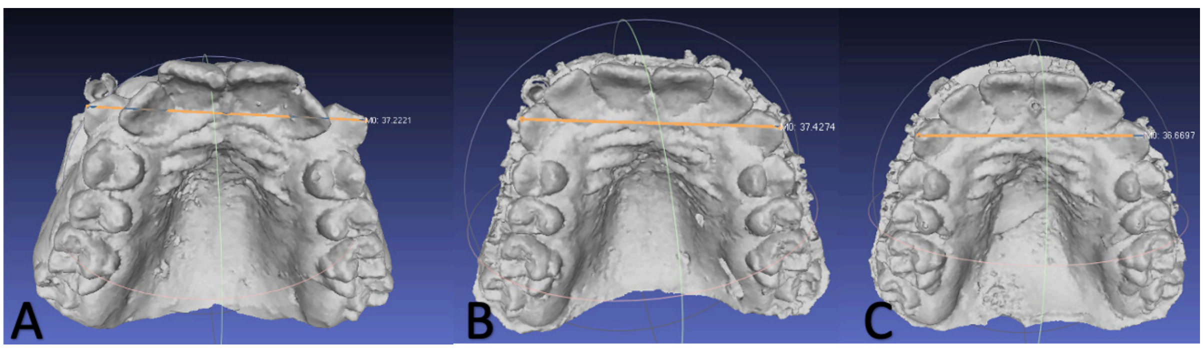

Figure 2. *Digital measurement of maxillary intercanine width **A.** Pretreatment **B.** 10th week of the treatment **C.** 20th week of the treatment.*

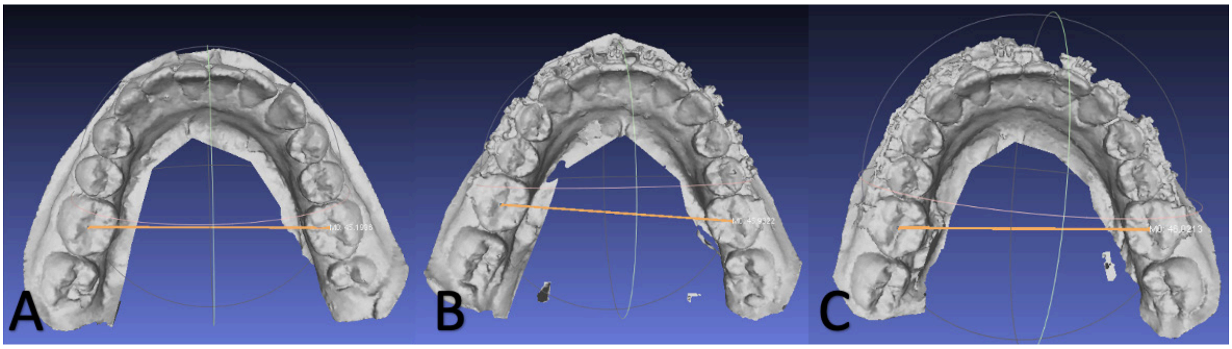

Figure 3. *Digital measurement of mandibular intermolar width* ***A.*** *Pretreatment* ***B.*** *10th week of the treatment* ***C.*** *20th week of the treatment.*

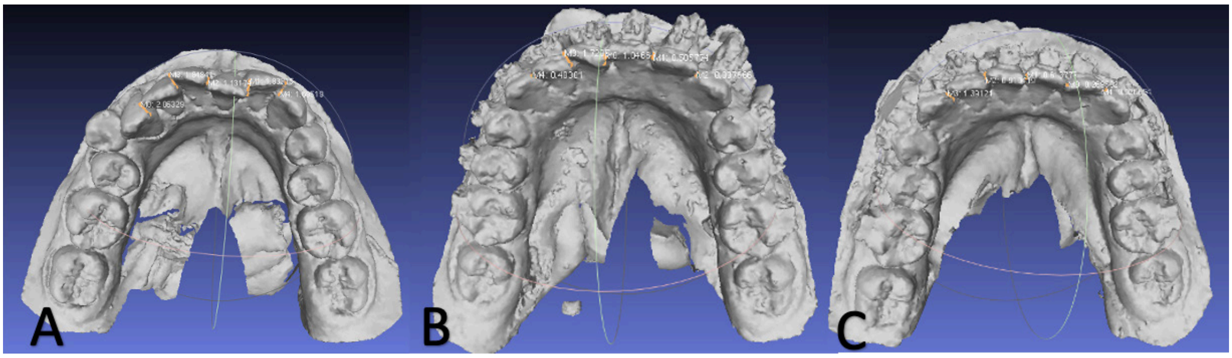

Figure 4. *Digital measurement of irregularity index* ***A.*** *Pretreatment* ***B.*** *10th week of the treatment* ***C.*** *20th week of the treatment.*

The patients were divided into Group 1 and Group 2 according to the type of bracket used in their treatment. Group 1 consisted of 17 patients (10 girls, 7 boys; mean age: 14.5 ± 2.0 years) and Damon Q (SDS Ormco, CA, USA) brackets with .022-inch slots were used in their treatment. Group 2 consisted of 18 patients (10 girls, 8 boys, mean age: 13.6 ± 1.9 years), and SmartClip SL3 (3M Unitek, Calif, USA) brackets with .022-inch slots were used in their treatment.

The archwire sequences were almost the same for both groups and the initial archwires were 0.014-inch nickel-titanium (NiTi). The first wire change was at the 10th week, and 0.016x 0.025-inch Damon copper NiTi arches were used in Group 1 (Damon arch form-Ormco, CA, USA) and 0.016x 0.025-inch NiTi heat-activated nickel-titanium (HANT) (OrthoForm™, 3M Unitek, Calif, USA) arch-wires were used in Group 2.

Plaster models at the beginning (T0), 10th week (T1), and 20th week (T2) of the treatment were scanned with a 7Series Dental Wings scanner (Dental - Wings Inc., Montreal QC, Canada). Digital models were obtained and saved in the 'STL' format. MeshLab software was used for the measurements of the digital models. Maxillary and mandibular intercanine (distance between the cusp tips of the right and left canines) and intermolar widths (distance between deepest and midpoint of the occlusal surfaces of the right and left first molars) and irregularity indexes were measured at T0, T1 and T2 time-lines (Figures 1, 2, 3 and 4). The amount of crowding of the anterior dentition (canine to canine) was measured by using Little's irregularity index.[26] All measurements were made by the same researcher who was blinded for the groups and intraobserver reliability was measured by remeasuring 20% of the data three weeks after the first measurement.

Statistical analysis

IBM SPSS Statistics 17.0 (IBM Corporation, Armonk, NY, USA) package program was used for statistical analysis. A post hoc power analysis was performed to determine the achieved power of the study. Reliability (repeatability) levels of the observer were investigated by intraclass correlation coefficient (ICC) and 95% confidence intervals. The Shapiro-Wilk test was used to evaluate the normal distribution of the data. The demographic statistical analysis was evaluated with Student's t-test and Chi-Square test. Intragroup intermolar and intercanine widths measurements for the follow-up times were evaluated with Student's t-test. Wilcoxon signed-rank test was used for intragroup comparisons of the irregularity index. Differences and decreasing rate of irregularity index for intergroup comparisons were examined with Mann-Whitney U test. Descriptive statistics are expressed as mean ± standard deviation. $P<0.05$ were considered statistically significant. Bonferroni correction was applied to control Type I error in all possible multiple comparisons.

RESULTS

The post hoc power calculation showed a sample power of 87% at $\alpha=0.05$. The intraclass correlation coefficient for intraobserver reliabilities ranged between 0.998-1.00 for all measurements. Demographic variables of the patients including age, sex, irregularity index, and Angle classification were found statistically similar between the groups (Table 1).

There were no significant differences between the maxillary and mandibular intercanine and intermolar widths of the groups at T0. No statistically significant differences were found for the treatment groups in the maxilla and mandible when changes in intermolar and intercanine widths were compared according to follow-up times (Table 2).

Changes in the irregularity index according to follow-up times for the treatment groups are given in Table 3. At the end of 20 weeks, the mean of the irregularity index was 0.39 mm in the Damon group and 0.37 mm in the SmartClip group for the maxilla. In the mandible, this measurement was 0.38 mm for the Damon group and

Table 1. *Demographics and clinical characteristics of the patients.*

	Group 1/Damon mean ± SD or %	Group 2/ SmartClip mean ± SD or %	P
Demographic characteristics			
Age (y)	14.50 ± 2.0	13.60 ± 1.9	0.172 †
Sex (%)			0.999 ‡
Male	7 (41.2%)	8 (44.4%)	
Female	10 (58.8%)	10 (55.6%)	
Clinical characteristics			
Maxillary Crowding (irregularity index, mm)	6.59 ± 1.6	6.32 ± 1.8	0.644 ¶
Mandibular Crowding (irregularity index, mm)	5.95 ± 1.7	5.73 ± 1.9	0.609 ¶
Angle class (%)			
Angle I	70.5	72.2	0.296 ‡
Angle II	23.5	22.2	0.169 ‡
Angle III	5.8	5.5	0.287‡

SD: Standard deviation.
† t test.
‡ X^2 test.
¶ Mann Whitney U test.

Table 2. *Intergroup comparisons of changes in intermolar and intercanine widths according to follow-up times.*

		Group 1/Damon (mean ± SD)	Group 2/SmartClip (mean ± SD)	P †
Intermolar width	**Maxilla**			
	T1-T0	0.41 ± 0.36	0.55 ± 0.39	0.276
	T2-T0	0.88 ± 0.52	1.17 ± 0.72	0.180
	T2-T1	0.46 ± 0.42	0.62 ± 0.71	0.455
	Mandible			
	T1-T0	0.43 ± 0.47	0.56 ± 0.35	0.327
	T2-T0	1.01 ± 0.62	1.18 ± 0.67	0.430
	T2-T1	0.58 ± 0.41	0.62 ± 0.48	0.816
Intercanine width	**Maxilla**			
	T1-T0	0.28 ± 1.02	0.93 ± 0.70	0.115
	T2-T0	0.57 ± 1.00	1.42 ± 1.23	0.113
	T2-T1	0.29 ± 0.80	0.49 ± 1.07	0.541
	Mandible			
	T1-T0	0.87 ± 1.09	0.90 ± 0.67	0.944
	T2-T0	1.19 ± 1.34	1.50 ± 1.10	0.461
	T2-T1	0.32 ± 0.44	0.61 ± 0.74	0.176

SD, standard deviation;
T0: pretreatment
T1: 10th week of the treatment
T2: 20th week of the treatment
† t-test results with Bonferroni Correction.

0.71 mm for the SmartClip group. When the means of the irregularity index measurements for the maxilla and mandible were examined at the T0, T1, and T2 timelines, no significant difference was found between the groups (Table 3). When the irregularity index changes between T0-T1, T0-T2, and T1-T2 were examined within the group, statistically significant decreases were found for both the maxilla and mandible with time (Table 3). It was shown that there was a significant decrease in the irregularity index in both groups within the examined timelines (Table 3).

The rate of the decrease in the irregularity index between the timelines is given as percentages in Table 4. In the maxilla, the decrease in the irregularity index was 93.78% in the Damon group and 94.35% in the SmartClip group at the end of 20 weeks (Table 4). In the mandible, the decrease in this index was 93.6% in the Damon group, while it was 88.11% in the SmartClip group (Table 4). Our null hypothesis was partly rejected because the rate of the decrease in the irregularity index between T0-T2 and between T1-T2 was found to be significantly higher for the Damon group in the mandible (P<0.05); however, there was no significant difference between the T0-T1 timeline (Table 4). There was no significant difference in the rate of decrease in the irregularity index between the groups in the maxilla (Table 4).

Discussion

Frictional forces occur between the archwire/bracket and archwire/ligature interfaces and approximately 12% to 60% of the clinically applied forces are lost by the friction. Low friction was found for different designs of SLBs, with passive ligation superior to active ligation.[6,27] Both of the SLBs compared in this study are passive SLBs, with completely different cap designs and bracket widths. Damon Q bracket has a cap design that closes the bracket from the buccal surface and creates a wide slot for the archwire.[28] However, the SmartClip bracket has unique nitinol clips that are not found in any other passive self-ligating bracket systems.[29] Due to

Table 3. *Changes in the irregularity index according to follow-up times for the treatment groups.*

Parameter (mm)	T0 (mean ± SD)	T1 (mean± SD)	T2 (mean ± SD)	P †
Maxilla				
Group 1/Damon	6.59 ± 1.6 [a, b]	2.04 ± 1.8 [a, c]	0.39 ± .37 [b, c]	**0.001**
Group 2/SmartClip	6.32 ± 1.8 [a, b]	2.07 ± .9 [a, c]	0.37 ± .35 [b, c]	**0.001**
P ‡	0.644	0.908	0.753	
Mandible				
Group 1/Damon	5.95 ± 1.7 [a, b]	2 ± 0.9 [a, c]	0.38 ± .36 [b, c]	**0.001**
Group 2/SmartClip	5.73 ± 1.9 [a, b]	2.41 ± 1.2 [a, c]	0.71 ± .52 [b, c]	**0.001**
P ‡	0.609	0.355	0.092	

[a] The difference between T0 and T1 is statistically significant.
[b] The difference between T0 and T2 is statistically significant.
[c] The difference between T1 and T2 is statistically significant.
T0: pretreatment
T1: 10th week of the treatment
T2: 20th week of the treatment
† Intragroup comparisons between follow-up times.
‡ Intergroup comparisons at each follow-up time.
SD, standard deviation;

Table 4. *The rate of decrease in the irregularity index.*

		Maxilla			Mandible		
		n	mean (%)	P †	n	mean (%)	P †
T0-T1	**Group 1/Damon**	17	68.97	0.741	17	66.67	0.113
	Group 2/SmartClip	18	67.71		18	59.59	
T1-T2	**Group 1/Damon**	17	80.15	0.895	17	81.64	**0.042**
	Group 2/SmartClip	18	82.24		18	71.45	
T0-T2	**Group 1/Damon**	17	93.78	0.895	17	93.6	**0.031**
	Group 2/SmartClip	18	94.35		18	88.11	

T0: pretreatment
T1: 10th week of the treatment
T2: 20th week of the treatment
† Mann Whitney U test.

this difference, this bracket system can also be defined as a semi-passive bracket.

Levelling efficiencies of two different SLBs were compared in patients who did not have any skeletal discrepancy and were treated with non-extraction mechanics so that the levelling period and the correction of crowding were tried to be followed with a standardized method in this retrospectively designed study. While measuring the efficiency for the initial levelling stage, the 10th and 20th weeks of the treatment were chosen which were previously suggested in the literature[18,30] and patients who had progress dental models at these stages were included in this study. Intercanine, intermolar widths, and Little's irregularity index were measured similar to previous studies were measured to investigate the levelling efficiency.[30,31] In the literature, no statistically significant difference was found between linear measurements made on digital and plaster models.[32,33] Therefore in this study, dental arch crowding was measured on digital models.

In the treatment of malocclusions characterized by crowding, if there is no active distalization and/or no extractions, crowding is solved by increasing the intermolar width.[34,35] Scott *et al.*[17] compared the effectiveness of Damon SLBs and conventional brackets in the mandible using the same archwires and found no significant difference between the groups for the increase in intercanine and intermolar widths. Pandis *et al.*[31] evaluated the effects of Damon SLBs and conventional brackets on the mandibular intercanine and intermolar widths and at the end of the levelling period, they found no difference in these widths. A recent study has investigated changes in arch widths with conventional brackets and dual-activation SLBs during levelling phase and concluded that both bracket systems provided equal changes in transversal arch dimensions.[25] In our study, an increase was found for the lower intercanine distance in both groups, but no significant difference was found between the groups.

Atik *et al.*[22] compared conventional brackets, and active and passive SLBs with broad archwires in terms of maxillary dental arch widths. They reported that intercanine, interpremolar, and intermolar widths were significantly greater after treatment with all bracket systems, but when the levels of expansion achieved among the groups were compared, no difference was found. Tecco *et al.*[14] reported that maxillary intercanine and intermolar widths increased with Damon SLBs and conventional brackets at the end of 12 months, but there was no significant difference between these two groups. In our study, in accordance with the results of Atik *et al*[22] and Tecco *et al.*[14], an increase was found in the intercanine and intermolar distances in the maxilla in both SLBs groups, but no significant difference was found between the groups.

Scott *et al.*[17] compared Damon SLBs and conventional brackets in terms of levelling efficiency for lower incisors. The initial mean irregularity index values were higher in the conventional bracket group than in the Damon group. After the levelling phase was completed, they measured the daily levelling amount as 0.135 mm/day for the conventional bracket group and 0.119 mm/day for the Damon group. They stated that the decrease in the initial crowding was not related to the bracket type, but related to the amount of initial crowding. Fleming *et al.*[36] investigated the effects of SmartClip SLBs and conventional brackets on levelling efficiency of mandibular crowding with 3D modeling. There was no significant difference between the two groups for the levelling efficiency in the 8th week. As a result, they reported that the bracket type does not have an effect on the levelling rate, and the initial crowding amount is proportional to the levelling amount. Considering these previous results, it was tried to include patients with similar crowding in our study groups. One of the inclusion criteria of this study was to include patients who had an irregularity index greater than 3 mm on both arches. At the end of the study, when mean pretreatment values of the irregularity index were compared, no significant difference was found between the groups.

Miles[18] conducted a study with 58 patients to compare the levelling effectiveness of SmartClip and conventional brackets in mandibular incisors. At the end of 20 weeks, SmartClip brackets did not show any superiority over conventional brackets in reducing irregularity.[18] Jahanbin *et al.*[23] compared the efficiency of Damon 3 SLBs and conventional MBT brackets during the four months of the alignment stage and more correction of the maxillary crowding was observed with SLBs, but the rate of alignment in the mandibular arch was not found to be different between two groups. A recent systematic review[24] has investigated the treatment efficiency of conventional, passive, and active SLBs and stated that the major difference between active and passive SLBs was that alignment was 10 days faster with active SLBs, but the treatment duration was not statistically different. In this study, both Damon and SmartClip SLBs groups were shown to effectively reduce the crowding of maxillary incisors. However, Damon SLBs showed more favorable results for the levelling ratio of the mandibular incisors.

Limitations

Our study groups were selected according to strict inclusion criteria but one of the limitations is the retrospective design of this study. Data collection was carefully made, but the patients were treated by two different clinicians. Another limitation is the inability to obtain information about the angular changes of the teeth due to the lack of radiological data on the intermediate stages.

Clinical significance

Different kinds of SLBs are currently available in the dental market and each manufacturer claims that their brackets have better treatment efficiency. However, clinical scientific evidence is more important than the claim. This study aimed to show which SLBs have better results in the levelling phase and to assist the clinician when choosing SLBs.

Conclusion

Both Damon and SmartClip SLBs groups were shown to effectively reduce crowding in maxillary incisors.

Increases in intercanine and intermolar widths were found to be similar in both Damon and SmartClip SLBs after 20 weeks.

Damon SLBs group was found to be better for the speed of the correction of crowding only for the lower incisor region.

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Kendinden bağlamalı iki farklı braket sisteminin başlangıç seviyeleme etkinliğinin karşılaştırılması

Özet

Amaç: Bu çalışmanın amacı, iki farklı pasif kendinden bağlamalı braketin (KBB) başlangıç seviyeleme etkinliğini değerlendirmek ve ark genişliği üzerindeki etkilerini karşılaştırmaktır.

Gereç ve Yöntem: Bu çalışmaya KBB'ler ile tedavi edilmiş, iskeletsel anomalisi olmayan, her iki arkta Little'ın irregülerite indeksi (LİI) 3 mm'den fazla olan ve tedavi başı (T0), tedavinin 10. (T1) ve 20. (T2) haftalarında hasarsız alçı modelleri mevcut olan hastalar dahil edilmiştir. Grup 1 (Damon) 17 hastadan (ortalama yaş=14.5 yıl), Grup 2 (SmartClip) ise 18 hastadan (ortalama yaş=13.6 yıl) oluşmuştur. Dental modeller taranarak dijital modeller elde edilmiştir. Maksiller-mandibular interkanin, intermolar genişlikler ve LİI'leri MeshLab yazılımı ile ölçülmüştür. İstatistiksel analiz için Wilcoxon ve Mann Whitney U testleri kullanılmıştır.

Bulgular: T0'da ortalama LİI açısından gruplar arasında anlamlı bir fark bulunmamıştır (maksiller LİI, Grup 1= 6.59 mm; Grup 2= 6.32 mm; mandibular LİI, Grup 1= 5.95 mm, Grup 2= 5.73mm). Mandibulada, LİI'deki azalma oranı Grup 1'de T0-T2 ve T1-T2 dönemleri arasında anlamlı derecede yüksek bulunmuştur ancak T0-T1 arasında anlamlı bir farka rastlanmamıştır (P=0.031, P=0.042, P=0.113). Maksillada, gruplar arasında LİI'deki azalma oranı açısından anlamlı bir fark yoktur. Takip sürelerine göre intermolar ve interkanin genişliklerindeki değişimler karşılaştırıldığında tedavi grupları arasında anlamlı bir fark bulunmamıştır.

Sonuç: Her iki KBB grubunun da maksiller arktaki çapraşıklığı etkili bir şekilde azalttığı gösterilmiştir. İnterkanin ve intermolar genişliklerdeki artışlar her iki grup için de benzer bulunmuştur. Grup 1, sadece alt kesici bölgesindeki çapraşıklığı düzeltme hızı açısından daha iyi bulunmuştur.

Anahtar Kelimeler: Ortodonti; ortodontik braketler; ortodontik gereçler.