Comparison of active self-ligating brackets and conventional pre-adjusted brackets

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Background: Active self-ligating brackets may be more efficient than conventional pre-adjusted brackets.

Aims: To determine if self-ligating brackets are more efficient than conventional pre-adjusted brackets when used in a specialist practice setting.

Methods: Seven hundred and sixty two patients, consecutively treated with fixed appliances, were evaluated retrospectively. All patients were treated by one orthodontist in a private orthodontic practice. Three hundred and eighty three patients were treated using a conventional pre-adjusted bracket system and 379 patients were treated with active self-ligating brackets. The total treatment time, number of appointments, appointment intervals, number of bracket breakages and number of unscheduled emergency appointments were recorded. Pretreatment characteristics identified by the ICON were related to these variables.

Results: The average treatment duration was 15.7 months (Range: 4.1–40.5 months; SD: 5.6 months). Comparable amounts of time were spent in rectangular and round archwires by both appliances. Overall, there was no statistically significant difference between the durations of treatment with active self-ligating brackets and conventional pre-adjusted brackets. The number of debonded brackets and other emergency visits was significantly higher in patients treated with active self-ligating brackets. The treatment characteristics associated with prolonged treatment were: extraction of teeth, a Class II molar relationship and the degree of maxillary crowding or spacing.

Conclusions: Active self-ligating brackets appear to offer no measurable advantages in orthodontic treatment time, number of treatment visits and time spent in initial alignment over conventional pre-adjusted orthodontic brackets.

(Aust Orthod J 2008; 24: 102–109)

Introduction

In recent years self-ligating brackets (SL) have been accepted by the profession as an alternative to conventional pre-adjusted orthodontic brackets. Some of the advantages claimed for self-ligating brackets over conventional brackets include: shorter treatment times, reduced friction, savings in chairside time, improved oral hygiene and patient comfort.[1–11] In spite of significant exposure of these brackets in the orthodontic marketplace there is limited in vivo evidence to support these claims.

The treatment efficiency of self-ligating brackets compared with conventional brackets has been measured at the end of treatment and at selected stages during treatment.[3,6,12,13] These studies, which are predominantly retrospective, have provided conflicting evidence: on one hand self-ligating brackets result in improved treatment efficiency and on the other that they offer no such advantage.[3,6,9,12,13] For example, Harradine reported a significant 4 month reduction in the duration of treatment when Damon SL brackets were compared with an unspecified conventional, pre-adjusted twin bracket.[3] More recently, Miles et. al. found no advantage in treatment efficiency when either SmartClip or Damon 2 SL brackets were compared with conventional brackets.[13,14] There is, however, one consistent finding from these studies which may impact on the efficiency and cost of treatment with self-ligating brackets: they have a higher rate of bond failure than conventional brackets.[3,6,9,12,15,16]

The aim of the present retrospective study is to determine if self-ligating brackets are more efficient than

conventional pre-adjusted brackets when used in a specialist practice setting.

Subjects and methods

Approval to conduct this study was obtained from the Human Research Ethics Committee of The University of Western Australia. All assessments were carried out in accordance with the guidelines of the National Health and Medical Research Council of Australia.

This study is a retrospective case analysis of 800 patients. The patients were treated with full fixed orthodontic appliances in a suburban, specialist orthodontic practice by an orthodontist with more than 20 years orthodontic experience. The records for each patient were retrieved from the practice database (Orthotrac, Kodak Dental Systems, Atlanta, USA). Group 1 consisted of 400 patients consecutively treated with conventional, pre-adjusted single wing 0.022 x 0.028 inch orthodontic brackets (Victory Series, 3M Unitek, Monrovia, CA, USA). Treatment for this group commenced in 1995. Group 2 comprised 400 patients consecutively treated using 0.022 x 0.028 inch active self-ligating brackets (InOvation, GAC Intl, Bohemia, NY, USA). Treatment for this group commenced in 2002, although these brackets had been used in the practice since 1999. The same archwire sequences and mechanics, including segmental mechanics where indicated, were used with both appliances and a number of patients in both groups had an initial phase of treatment with either the Herbst or pendulum-type appliances. After this initial treatment a significant period of 'settling' followed before fixed appliances were placed. Combined surgical-orthodontic patients were excluded from both groups.

All cases were bonded using direct bonding and the same orthodontic bonding agent (Transbond, 3M Unitek, Monrovia, CA). Of the 800 patients, 38 were excluded because they were transferred to another orthodontist or because their records were missing or incomplete. Of the 762 remaining, 383 were treated with pre-adjusted brackets (Group 1) and 379 were treated with active self-ligating brackets (Group 2).

The duration of treatment (3-month intervals), the number of appointments and length of time each type of archwire was used (months) were recorded from the time an appliance was bonded to the time it was removed. From this information, it was possible to determine the durations that round and rectangular

archwires were used. Appointments used solely for oral hygiene instruction and unscheduled emergency appointments were excluded. Unscheduled emergency visits for reasons other than bracket failures were separately tallied for each patient. Bracket bond failures during the course of appliance treatment were tallied as an overall figure for each patient. Molar attachment breakages were not included in this assessment.

Statistical methodology

The associations and inter-relationships between the number of bracket breakages, the timing of breakages, the number of non-bracket related emergency visits, the pretreatment molar relationship (Angle's classification), the presence/absence of orthodontic extractions on the duration of treatment, the number of treatment visits and the appointment intervals were determined. To determine if the groups were similar at the start of the study and at the end of treatment, the pretreatment and post-treatment study models were assessed with the Index of Complexity, Outcome and Need (ICON).[17] For completeness the ICON score and the two components that make up the ICON score were used in separate analyses to look for associations with the aforementioned treatment characteristics.

A general linear model approach was used to examine the effects of the method of ligation ('Conventional' or 'Self-ligating'), malocclusion ('Class I', 'Class II' or 'Class III') and extraction of teeth ('Yes' or 'No') against the treatment duration, the number of scheduled appointments and the number of days either round or rectangular archwires were used. Due to the nature of the data, which in most cases was in the form of counts, a square root variance stabilising transformation was carried out when necessary and the analysis performed on the transformed variables. Each of the three factors and their interactions were examined and retained in the final model if they satisfied the 0.05 level of significance. Pairwise comparisons were made to determine whether or not the differences at the specific levels were statistically significant.

A two-stage analysis was then performed to assess the number of bond failures and the number of unscheduled emergency appointments. Initially a logistic regression approach was used to determine whether or not bond failures ('Yes' or 'No') or unscheduled

Table I. Treatment duration and number of scheduled appointments in patients treated with conventional and active self-ligating brackets.

		Conventional/pre-adjusted			Self-ligating		
		Number (%)	Treatment duration (Months) Mean (SD)	Scheduled appointments Mean (SD)	Number (%)	Treatment duration (Months) Mean (SD)	Scheduled appointments Mean (SD)
Molar relationship	Class I	169 (44)	15.0 (6.0)	12.5 (4.7)	131 (34)	14.7 (4.7)	12.1 (4.0)
(Angle's class)	Class II	202 (53)	16.5 (6.0)	13.9 (5.3)	223 (59)	15.9 (5.4)	12.7 (4.4)
	Class III	12 (3)	17.7 (8.4)	14.7 (7.2)	25 (7)	17.2 (5.5)	13.5 (5.8)
Extractions	Yes	102 (27)	18.2 (6.5)	15.3 (5.8)	76 (20)	18.5 (5.5)	16.0 (5.7)
	No	281 (73)	15.1 (5.8)	12.6 (4.7)	303 (80)	14.8 (4.8)	11.7 (3.5)
Overall		383	15.9 (6.1)	13.3 (5.1)	379	15.6 (5.2)	12.5 (4.4)
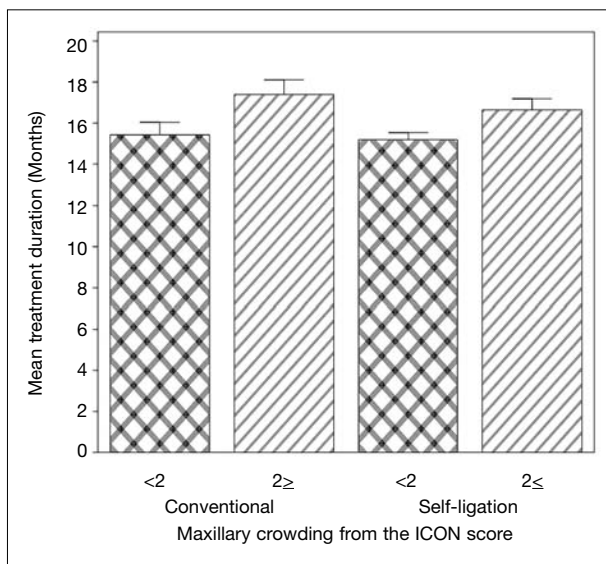
Figure 1. Effect of maxillary crowding/spacing (ICON components) on the duration of treatment in patients with conventional and active self-ligating brackets.

appointments ('Yes' or 'No') were influenced by the type of ligation, Angle class or extraction of teeth. Odds ratios are presented for significant effects. The second stage involved conditional analyses on the number of bond failures and the number of unscheduled emergency appointments. These analyses were conditional on the patient having some bond failures or some unscheduled emergency appointments respectively. A generalised linear model approach was used with reciprocal link and gamma distribution. Differences in means with the significance of effects are presented.

Examination of the differences between the number of emergency appointments and rebonds over time in both treatment groups was performed, comparing the two groups with a non-parametric test at each time point. Due to the number of tests used, the significance levels were adjusted with the Bonferroni correction.

The pre- and post-treatment ICON scores in both groups were compared and a linear mixed model was used to assess the ICON score, the method of ligation and treatment time. The random effect of person was included to allow for measurements being taken twice on each individual. Paired comparisons were made between conventional and self-ligation for pre- and post-ICON scores and the same comparison between conventional and self-ligation was made on the difference ('Increase' or 'Decrease') from pre- to post-treatment. Due to incomplete data, separate analyses examined the impact of pretreatment crowding in both groups (based on the ICON score) on the total treatment times. Again, a general linear model approach was used.

Results

There were no significant group differences in the durations of treatment and the number of appointments (Mean treatment duration: Group 1 (conventional, pre-adjusted brackets), 15.8 months; Group 2 (self-ligating brackets), 15.5 months. Number of appointments: Group 1, 13.2; Group 2, 12.5). The number of patients in each group, the pretreatment molar relationships and whether or not orthodontic extractions were carried out are given in Table I. The type of malocclusion and extraction of teeth had statistically significant effects on the total number of appointments. Patients with a Class II molar relationship required more appointments (6–7 per cent) than patients with a Class I molar relationship

Table II. Unscheduled appointments and bracket bond failures in patients treated with conventional and active self-ligating brackets.

		Conventional/pre-adjusted		Active self-ligating	
		Unscheduled emergency appointments Mean (SD)	Bracket bond failures Mean (SD)	Unscheduled emergency appointments Mean (SD)	Bracket bond failures Mean (SD)
Molar relationship (Angle class)	Class I	2.1 (2.5)	1.2 (2.0)	3.0 (2.6)	3.2 (3.0)
	Class II	2.3 (2.3)	1.2 (1.6)	2.9 (2.9)	3.0 (2.7)
	Class III	2.5 (4.1)	1.4 (1.3)	2.8 (2.6)	2.2 (2.6)
Extractions	Yes	2.7 (3.1)	1.2 (2.0)	3.0 (2.8)	2.1 (2.4)
	No	2.1 (2.1)	1.3 (1.7)	2.9 (2.8)	3.2 (2.9)
Overall		2.2 (2.5)	1.2 (1.8)	2.9 (2.8)	3.0 (2.8)
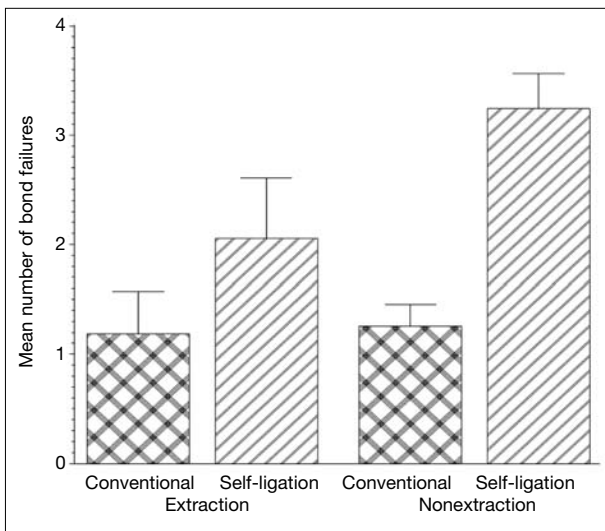
Figure 2. Bond failures in the extraction and nonextraction patients with conventional active self-ligating brackets.

(p = 0.016). Treatment also took 26 per cent longer (p = 0.005) and required 26 per cent more appointments (p < 0.001) in patients who had extractions compared with the patients who were treated non-extraction.

Maxillary crowding/spacing, as determined by the ICON score, and the durations of treatment in the conventional and self-ligating groups are shown in Figure 1. No statistically significant differences were found between the two groups with respect to the degree of pretreatment maxillary crowding/spacing. Since there were few patients with ICON scores 3–5 the patients were classified into two groups: those with mild crowding/spacing (ICON scores < 2) and those with moderate to severe crowding/spacing

(ICON scores $\geq$2). Of the 762 patients investigated only 44 had ICON scores between 3 and 5. The number of patients with moderate to severe crowding/spacing (ICON score $\geq$2) was associated with significantly longer treatment when compared with patients with mild crowding/spacing (ICON score <2) for both bracket types (Mean difference: 1.7 months, p = 0.01).
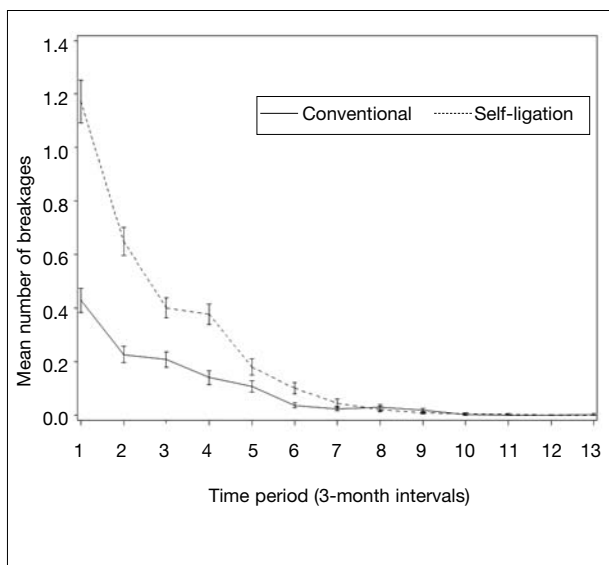
More patients treated with active self-ligating brackets experienced bond failures than patients treated with conventional brackets: 80.2 per cent and 53.0 per cent respectively (Odds ratio: 3.52; 95% CI: 2.55, 4.87). When the analysis conditional on having bond failure was carried out, patients in the self-ligating group had significantly more bond failures than those in the conventional group (Mean difference in bond failures: 1.41; p < 0.001). The molar relationship (Angle class) and extraction/nonextraction did not influence the outcome (Table II).

When the patients who had emergency appointments were analysed, patients treated with self-ligating brackets had significantly more appointments than patients treated with conventional brackets (Mean difference in the number of appointments: 0.45; p = 0.005). In addition, the number of unscheduled emergency appointments was significantly higher in patients who had extractions as compared with those who were treated nonextraction for both self-ligating and conventional groups (Mean difference in number of appointments: 0.37; p = 0.037).

The number of bond failures in the extraction and nonextraction groups is shown in Figure 2. Of the extraction patients, 56.7 per cent had bond failures

Table III. Durations round and rectangular archwires used in patients treated with conventional and self-ligating brackets.

| | | | Conventional/pre-adjusted | | | | | Active self-ligating | | | |
| | | Samples | Round (Months) Mean (SD) | | Rectangular (Months) Mean (SD) | | Samples | Round (Months) Mean (SD) | | Rectangular (Months) Mean (SD) | |
			Upper	Lower	Upper	Lower		Upper	Lower	Upper	Lower
Molar relationship (Angle's class)	Class I	169(44%)	4.9(4.0)	4.7(3.6)	9.7(4.4)	9.8(4.7)	131(34%)	4.5(2.4)	4.6(2.6)	9.2(4.3)	9.2(4.1)
	Class II	202(53%)	4.5(3.3)	4.6(3.1)	11.5(4.9)	11.2(5.2)	223(59%)	4.7(2.9)	5.0(2.9)	10.3(4.7)	10.2(4.8)
	Class III	12(3%)	5.4(4.3)	4.7(2.7)	11.8(8.0)	12.6(7.5)	25(7%)	5.9(3.2)	5.1(2.3)	9.9(4.3)	10.7(4.4)
Extractions	Yes	102(27%)	5.1(3.6)	5.3(3.5)	12.4(4.8)	12.1(5.1)	76(20%)	4.5(2.8)	4.9(2.9)	12.8(5.2)	12.3(5.5)
	No	281(73%)	4.5(3.7)	4.4(3.2)	10.1(4.8)	10.1(5.0)	303(80%)	4.8(2.8)	4.8(2.8)	9.2(4.0)	9.3(4.0)
Overall		383	4.7(3.7)	4.6(3.3)	10.7(4.9)	10.7(5.1)	379	4.7(2.8)	4.9(2.8)	9.9(4.5)	9.9(4.5)

Figure 3. Breakages over time in patients with conventional and active self-ligating brackets.
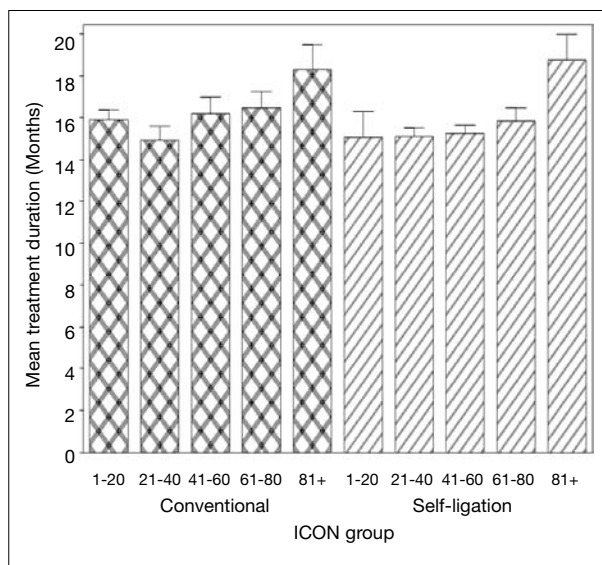
Figure 4. Treatment duration in patients treated with conventional and active self-ligating brackets, arranged in ascending pretreatment ICON scores.

independent of type of ligation, whilst in the non-extraction patients, 69.5 per cent experienced bond failures (Odds ratio:1.62; 95% CI: 1.13, 2.32).

The mean number of orthodontic breakages over the course of treatment can be seen in Figure 3. Time periods are given in 3-month intervals. From the data, it is evident that the majority of breakages occurred during the early stages of treatment. Statistically significantly more breakages occurred in the self-ligating group in the first six time periods i.e. 18 months (All time periods, $p < 0.05$).

The lengths of time round and rectangular archwires were used are given in Table III. Statistically signifi-

cantly more time was spent using rectangular arch-wires in the upper and lower arches in Class II mal-occlusions compared with Class I malocclusions, when conventional pre-adjusted brackets were used and if extractions had been carried out (All, $p < 0.05$). Round archwires were also used for significantly longer periods of time in the upper arch in extraction patients treated with conventional brackets as compared with patients treated with self-ligating brackets. Round archwires were, however, used for a significantly shorter period of time in the lower arch in the conventional nonextraction group than the self-ligation nonextraction group (All, $p < 0.05$). Overall

Table IV. Comparison of ICON scores in patients treated with conventional (N = 383) and active self-ligating brackets (N = 379).

	Conventional Mean (SD)	Active self-ligating Mean SD
Pretreatment score	49.9 (19.6)	48.0 (20.4)
Post-treatment score	7.6 (1.6)	7.8 (2.0)
Decrease (Per cent)	82.2 (8.4)	80.6 (9.0)

there was no statistically significant difference in the durations round archwires were used in the conventional and self-ligating extraction groups. Since the durations of treatment were the same in both groups, if round wires were used for a short period of time more time was spent in rectangular wires and vice versa.

There were no statistically significant differences between the two groups in the pre- and post-treatment ICON scores and the decrease in ICON scores over treatment (Table IV). High pre-treatment ICON scores were found to be positively associated with longer durations of treatment (Figure 4).

Discussion

In agreement with previous studies including several small prospective studies, we found no significant differences in the durations of treatment or the number of appointments required to treat patients with either conventional pre-adjusted brackets or self-ligating brackets.[12–15,16] A few previous studies with relatively small numbers of randomly selected or matched cases have reported shorter treatment times with self-ligating systems.[3,4] The mean treatment durations for the conventional and active self-ligating bracket groups in our study are 15.8 and 15.5 months respectively. These figures, which are shorter than the treatment durations reported in previous studies, do not include any initial treatment carried out on many Class II and nonextraction malocclusions in both groups with the Herbst or pendulum type appliances. When these appliances were used, a significant period of settling followed before placing the fixed appliances.[3,7,18–21] The mean interval between appointments was 5 weeks in both groups, which falls within normal limits.[19] Selective use of segmental mechanics with both bracket systems, and particularly the conventional single wing appliance, may have

contributed to the relatively short treatment times we found when compared with other studies.[3,7,18–21]

One of the strengths of the present study is that we used large samples of patients consecutively treated with either conventional pre-adjusted brackets or self-ligating brackets.[3,4,8,13,14] Whereas previous studies have compared the treatment efficiency of self-ligating brackets with conventional pre-adjusted twin brackets, we used pre-adjusted single wing brackets, which is one of the limitations of the present study.[3,4,13,14] The self-ligating bracket we used had twin wings. Further limitations of our study are that it was a retrospective study, all treatments were carried out by the same clinician and the sequence of archwires was determined by each patient's response rather than a predetermined sequence or stage of treatment.

We found a high number of bond failures (54 per cent) in the active self-ligating bracket group.[3,13] These findings disagree with a previous study, which reported equivalent breakage rates for a passive self-ligating system and edgewise brackets. The higher failure rate in our study may be due to the bracket profile, the base design and/or the active clip.[21] As a rule, bracket breakages prolong the duration of treatment and should be avoided if possible.[15,18–20] It could be postulated that active self-ligating brackets will outperform their conventional bracket counterparts when the problem of breakage/bond failure is solved.[13,22] The majority of breakages occurred during the levelling and alignment phases of treatment and, somewhat surprisingly, there were fewer breakages if teeth had been extracted. The flexibility in long archwire spans in patients following premolar extractions may have contributed to this finding.

Although small, statistically significant differences were found in the time spent in round wires for initial alignment between conventional and self-ligating appliances, these differences amounted to 2–3 weeks at the most across all groups. It was noted that when less time was spent in round wires more time was spent in rectangular wires, which resulted in no difference in overall treatment time. An exception occurred in patients with Class I malocclusions: the treatment times for both round and rectangular wires were shorter in the self-ligating group.

The present study confirms a recent report that the degree of maxillary crowding, extraction of teeth and

a pretreatment Class II molar relationship contribute to longer treatment times.[18] Our results failed to demonstrate that self-ligating brackets aligned crowded/spaced maxillary teeth, regardless of the degree of pretreatment crowding/spacing, more quickly than conventional brackets. A recent study has provided similar findings.[20] On average, malocclusions with severely crowded/spaced maxillary teeth took longer to treat than malocclusions with mild/no maxillary crowding. Although treatment took slightly longer and required more appointments when self-ligating brackets were used in extraction patients, nonextraction patients were treated in a shorter period of time with fewer appointments. There were similar numbers of nonextraction cases in both groups: 73 per cent and 80 per cent. We also found patients with a pretreatment Class II molar relationship required more appointments than patients with a Class I molar relationship.

Malocclusions of equal difficulty, as determined by the pretreatment ICON, would presumably be treated in the same time frame by both brackets. Furthermore, patients can expect the quality of the final outcome to be equal, as demonstrated by the post-treatment ICON, irrespective of the bracket type employed. These findings may reflect shortcomings in the sensitivity of the ICON as a measure of patient complexity and outcome, although several studies have demonstrated that the ICON is an acceptable method of measuring treatment outcome.[23–25]

Despite the failure of this study to demonstrate the superiority of active self-ligating brackets over conventional pre-adjusted brackets in terms of treatment efficiency, small savings in chairside time with self-ligating brackets may exist.[9] We could not detect if less time was spent manipulating a particular appliance because we could not identify the time spent on oral hygiene instruction, discussions with the parent and/or patient and unscheduled emergency visits which may have been performed by another clinician. Therefore, chairside efficiency, that is the time spent manipulating an appliance, was not measured in the present study.

Conclusions

The results of this retrospective study indicate that active self-ligating brackets and conventional pre-adjusted orthodontic brackets treat malocclusions in similar periods of time and with a similar number of appointments.

The following factors were found to prolong treatment irrespective of the type of bracket: a Class II molar relationship, extraction of teeth, greater complexity of the case (as measured by the ICON) and the severity of maxillary crowding/spacing.

More breakages/bond failures occurred with active self-ligating brackets than with conventional brackets. The majority of the breakages/bond failures occurred in the early stages of treatment.

Both bracket types treated malocclusions to the same standard.

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