An Evaluation of Efficiency and Effectiveness of Self-ligating Bracket Systems: A Prospective Clinical Study

Divya Singla, Mala Ram Manohar, Litesh Singla, G Shivaprakash

ABSTRACT

Objectives: Self-ligating brackets are becoming more common in the marketplace with many manufacturers offering one form or another. A number of studies have evaluated the frictional characteristics of different self-ligating brackets but there have been only few studies which have actually evaluated their clinical efficiency. The present study was done to compare the efficiency and effectiveness of three contemporary self-ligating bracket systems (Smart Clip, Damon 2, In-Ovation).

Materials and methods: This was a prospective in vivo study in which a total of 18 patients were randomly divided into three groups treated with Smart Clip, Damon 2 and In-Ovation bracket systems. The total treatment time and the number of appointments required to complete the treatment were recorded. As a measure of quality of treatment, the ABO scores were measured at the end of treatment from the post-treatment dental casts and OPG.

Results: The average time taken for the completion of treatment in Smart Clip, Damon 2, and In-Ovation group was 14.0 ± 2.6, 15.3 ± 3.2 and 17.2 ± 3.2 months respectively. The total number of appointments required for the completion of treatment in Smart Clip, Damon 2, and In-Ovation group were 16.0 ± 2.5, 16.8 ± 3.3 and 19.8 ± 2.6 respectively. The mean ABO score in Smart Clip, Damon 2, and In-Ovation group were 26.2 ± 1.0, 27.5 ± 2.3 and 27.0 ± 1.3 respectively.

Interpretation and conclusion: There was no statistically significant difference in the treatment time, number of appointments and quality of treatment outcome between the three bracket systems.

Keywords: Self-ligating brackets, Treatment time, ABO score.

INTRODUCTION

Orthodontic mechanotherapy is heavily dependent on material science and design. Bracket design and archwires greatly influence the efficiency of treatment. There has been a continuous ongoing research for better and faster methods of treatment.

The last 10 years saw a resurgence of self-ligating brackets of different types sparking off controversies on the efficiency of bracket design and treatment efficiency. Mainly two types of self-ligating brackets have been developed: Those with a spring clip that presses against the archwire (‘active’ SLBs) and those with a clip that does not press against the archwire (‘passive’ SLBs). With every self-ligating bracket, whether active or passive, the movable fourth wall of the bracket is used to convert the slot into a tube.1

A number of studies1-17 have been undertaken to compare the self-ligating brackets with conventional brackets, however, there is a lack of studies which have actually compared the clinical efficiency of the different type of self-ligating brackets designs.

This study was undertaken to investigate whether the different self-ligation methods affect the clinical efficiency and success of the treatment.

This study aims to compare three commonly used self-ligating bracket systems with regard to final finishing, treatment time and number of patient appointments.

The research question posed was which bracket system is more superior in terms of final finish, treatment time and number of patient appointments.

The objectives of the study included comparison of efficiency of three contemporary self-ligating bracket systems and to evaluate whether there are any differences in treatment time and number of appointments required to complete the treatment.

The study also evaluated the quality of treatment outcome by measuring post-treatment study models and radiographs.
using the grading criteria for certification as set by the American Board of Orthodontics (ABO). 

MATERIALS AND METHODS

Eighteen patients were selected from the patients seeking orthodontic treatment. The selection of patients in the sample was such that there was an even distribution of extraction and nonextraction cases in the parent sample.

Inclusion Criteria

• Patients having full complement of permanent teeth
• Patients having dental Class I or II malocclusion
• Patients within the age range of 16 to 25 years
• Patients requiring first premolar extraction in the extraction group.

Exclusion Criteria

• Periodontal compromised patients
• Patients requiring surgical intervention
• Patients with impacted teeth
• Patients with oral manifestations of disease
• Non-cooperative patients
• Patients having poor oral hygiene.

The study was aimed at an evaluation of efficiency and effectiveness of different self-ligating brackets. Three self-ligating brackets were investigated in this study:

a. Smart Clip (3M Unitek) (Fig. 1A)
b. Damon 2 (Ormco) (Fig. 1B)
c. In-Ovation (GAC International) (Fig. 1C).

The patients included in the study were equally divided into three groups of 6 patients each:

• Group 1: Patients treated with Smart-Clip self-ligating bracket system (Fig. 2)
• Group 2: Patients treated with Damon 2 self-ligating bracket system (Fig. 3)
• Group 3: Patients treated with In-Ovation self-ligating bracket system (Fig. 4).

The treatment was carried out as per the guidelines given by MBT. These three groups of patients were compared for treatment efficiency and effectiveness.

The two principal measures of treatment efficiency were:
1. The treatment time in months from 1st placement of fixed appliances to their removal and,
2. The number of appointments during this time: The records of number of visits were maintained for each visit the patient made for treatment, in all the three groups.

As a measure of effectiveness (quality) of treatment, the ABO scores were measured at the end of treatment from the post-treatment dental casts and OPG.

STATISTICAL ANALYSIS

Results were expressed as mean ± SD and range values. One way ANOVA was used for multiple group comparisons followed by post hoc Tukey’s test for group wise comparisons. A p-value of 0.05 or less was considered for statistical significance.

RESULTS

Treatment Time (Tables 1 and 2)

Average treatment time to complete treatment with Smart Clip self-ligating brackets was 14.0 ± 2.6 months, with Damon 2 it was 15.3 ± 3.2 months whereas with In-Ovation brackets it was 17.2 ± 3.2 months. The mean difference in treatment time between Smart Clip and Damon 2 self-ligating brackets was 1.3 months, between Smart Clip and In-Ovation it was 3.2 months and the difference between Damon 2 and In-Ovation was 1.9 months. This showed that Smart Clip brackets reduced the treatment time by 3.2 months when compared with In-Ovation brackets and by 1.3 months when compared with Damon 2 brackets. Damon 2 brackets took 1.9 months less as compared to In-Ovation brackets. The differences in mean treatment time between the three groups were not statistically significant.
Number of Appointments (Tables 1 and 2)
The mean number of appointments required to complete treatment with Smart Clip self-ligating brackets was $16 \pm 2.5$, with Damon 2 brackets, it was $16.8 \pm 3.3$ while with In-Ovation brackets, it was $19.8 \pm 2.6$. This showed that patients in Smart Clip appliance group required 0.8 appointments less to get their treatment completed as compared to Damon 2 brackets and 3.8 appointments less as compared to In-Ovation brackets. Patients in Damon 2 group required 3.0 appointments less to get their treatment completed as compared to In-Ovation brackets. The differences in mean number of appointments between the three groups were not statistically significant.

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Smart Clip</th>
<th>Damon 2</th>
<th>In-Ovation</th>
<th>ANOVA</th>
<th>F*</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time taken (months)</td>
<td>$14.0 \pm 2.6$</td>
<td>$15.3 \pm 3.2$</td>
<td>$17.2 \pm 3.2$</td>
<td>1.67</td>
<td>0.22 (NS)</td>
<td></td>
</tr>
<tr>
<td>Appointments (number)</td>
<td>$16.0 \pm 2.5$</td>
<td>$16.8 \pm 3.3$</td>
<td>$19.8 \pm 2.6$</td>
<td>3.06</td>
<td>0.08 (NS)</td>
<td></td>
</tr>
<tr>
<td>ABO score (deductions)</td>
<td>$26.2 \pm 1.0$</td>
<td>$27.5 \pm 2.3$</td>
<td>$27.0 \pm 1.3$</td>
<td>1.01</td>
<td>0.39 (NS)</td>
<td></td>
</tr>
</tbody>
</table>

* One-way ANOVA; NS: Nonsignificant
Table 2: Descriptive statistics for group-wise comparison between the three bracket systems

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Smart Clip vs Damon 2</th>
<th>Smart Clip vs In-Ovation</th>
<th>Damon 2 vs In-Ovation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean difference</td>
<td>p**</td>
<td>Mean difference</td>
</tr>
<tr>
<td>Time taken (months)</td>
<td>1.3</td>
<td>0.73 (NS)</td>
<td>3.2</td>
</tr>
<tr>
<td>Appointments (number)</td>
<td>0.8</td>
<td>0.87 (NS)</td>
<td>3.8</td>
</tr>
<tr>
<td>ABO score (deductions)</td>
<td>1.3</td>
<td>0.36 (NS)</td>
<td>0.8</td>
</tr>
</tbody>
</table>

** Post hoc Tukey’s test; NS: Nonsignificant

** ABO Scores

The parameters that were used to evaluate the final ABO scores of the patients in the three groups were alignment, marginal ridges, buccolingual inclination, occlusal relationship, occlusal contacts, interproximal contacts, overjet, and root angulation. The mean of individual component of ABO scores for the three groups is tabulated in Table 3.

The mean of total ABO score for Smart Clip self-ligating brackets was 26.2 ±1.0, for Damon 2 it was 27.5 ± 2.3 and for In-Ovation, it was 27 ± 1.3. The mean difference in ABO score of Smart Clip and Damon 2 was 1.3, between Damon 2 and In-Ovation it was 0.5 and between In-Ovation and Smart Clip 0.8. The differences in mean ABO scores between the three groups were not statistically significant (Tables 1 and 2).
Table 3: Descriptive statistics for individual ABO scores of the three bracket systems

<table>
<thead>
<tr>
<th></th>
<th>Alignment</th>
<th>Marginal ridges</th>
<th>Bucco-lingual inclination</th>
<th>Occlusal relation</th>
<th>Occlusal contacts</th>
<th>Interproximal contacts</th>
<th>Overjet</th>
<th>Root angulation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smart Clip</td>
<td>4.2 ± 0.8</td>
<td>4.5 ± 1.0</td>
<td>3.8 ± 0.8</td>
<td>4.2 ± 0.8</td>
<td>4.0 ± 1.4</td>
<td>1.2 ± 0.8</td>
<td>1.8 ± 1.0</td>
<td>2.5 ± 0.5</td>
</tr>
<tr>
<td>Damon 2</td>
<td>6.3 ± 0.8</td>
<td>4.3 ± 0.8</td>
<td>3.7 ± 0.5</td>
<td>3.8 ± 1.8</td>
<td>3.9 ± 1.7</td>
<td>0.8 ± 1.0</td>
<td>1.8 ± 1.5</td>
<td>2.8 ± 0.8</td>
</tr>
<tr>
<td>In-Ovation</td>
<td>3.8 ± 0.8</td>
<td>4.5 ± 1.4</td>
<td>3.8 ± 0.8</td>
<td>4.0 ± 0.6</td>
<td>3.8 ± 1.0</td>
<td>1.0 ± 0.9</td>
<td>2.8 ± 1.3</td>
<td>3.2 ± 0.8</td>
</tr>
<tr>
<td>Anova F*</td>
<td>18.4</td>
<td>0.05</td>
<td>0.12</td>
<td>0.12</td>
<td>0.03</td>
<td>0.21</td>
<td>1.22</td>
<td>1.40</td>
</tr>
<tr>
<td>p</td>
<td>&lt;0.01 (S)</td>
<td>0.96 (NS)</td>
<td>0.89 (NS)</td>
<td>0.89 (NS)</td>
<td>0.97 (NS)</td>
<td>0.81 (NS)</td>
<td>0.32 (NS)</td>
<td>0.28 (NS)</td>
</tr>
<tr>
<td>Smart Clip vs Damon 2**</td>
<td>&lt;0.01 (S)</td>
<td>0.96 (NS)</td>
<td>0.91 (NS)</td>
<td>0.91 (NS)</td>
<td>0.97 (NS)</td>
<td>0.79 (NS)</td>
<td>1.0 (NS)</td>
<td>0.69 (NS)</td>
</tr>
<tr>
<td>Smart Clip vs In-Ovation**</td>
<td>0.74 (NS)</td>
<td>1.00 (NS)</td>
<td>1.00 (NS)</td>
<td>1.00 (NS)</td>
<td>0.98 (NS)</td>
<td>0.94 (NS)</td>
<td>0.39 (NS)</td>
<td>0.25 (NS)</td>
</tr>
<tr>
<td>Damon 2 vs Inovation**</td>
<td>&lt;0.01 (S)</td>
<td>0.96 (NS)</td>
<td>0.91 (NS)</td>
<td>0.91 (NS)</td>
<td>1.00 (NS)</td>
<td>0.94 (NS)</td>
<td>0.38 (NS)</td>
<td>0.69 (NS)</td>
</tr>
</tbody>
</table>

*One-way ANOVA; **Post hoc Tukey’s test; S: Significant; NS: Nonsignificant

DISCUSSION

Numerous studies have demonstrated a dramatic decrease in friction for SLBs, compared to conventional bracket designs.1-4,8-11,20-26 Such a reduction in friction can help shorten overall treatment time, especially in extraction cases where tooth translation is achieved by sliding mechanics.

The design of a self-ligating bracket affects its frictional properties. Whether the archwire contacts the slide or the clip...
A hypothesis given by Harradine states that the active SLBs responsible for such observations may be the means of ligation. All other factors being equal, the only main variable not statistically significant.

Though a number of studies have been undertaken to compare the self-ligating brackets with conventional brackets, there have been no studies which have compared the clinical efficiency of the different types of self-ligating brackets.

The purpose of our study was two fold: First, the efficiency of three contemporary self-ligating brackets with different methods of engagement of the archwire was compared by evaluating for any difference in the treatment time and in the number of appointments required to complete the treatment. Second, the effectiveness or the quality of the treatment outcome of these self-ligating brackets was compared by evaluating post-treatment study models and panoramic radiographs using the grading criteria for certification as set by the ABO.

Three bracket systems with different self-ligation mechanisms were included in our study—Smart Clip, Damon and In-Ovation self-ligating brackets. The In-Ovation bracket is an active twin self-ligating bracket with a sliding spring clip made of stainless steel which encroaches on the slot from the labial aspect, potentially placing an active force on the archwire. The Damon 2 bracket is a passive single wing self-ligating bracket with a single slide to entrap the archwire which creates a passive labial surface to the slot with no intention or ability to invade the slot or store force by deflection of the metal clip. The Smart Clip bracket is a passive twin self-ligating bracket which engages the wire by NiTi clips adjacent to the wings and contains no moving door or latch. It has a familiar tie-wing design which allows for the use of traditional ligation as an option to the clinician.

**Treatment Time and No. of Appointments**

The Smart Clip patients required the least amount of treatment time, followed by the Damon 2 group. The In-Ovation patients required the maximum amount of time. However, this difference in treatment time between the three groups was not statistically significant.

All other factors being equal, the only main variable responsible for such observations may be the means of ligation. A hypothesis given by Harradine states that, the active SLBs also act as passive brackets when using a wire of dimension less than 0.018". Because the active clip effectively reduces the slot depth from 0.027" to approximately 0.018", the potentially active clip will be passive and irrelevant during leveling and aligning when using wires of dimension less than 0.18". So the difference in treatment time observed between the three brackets might not be during the leveling and aligning stage of the treatment and more likely to have occurred during the space closure and finishing stages of treatment.

The longer treatment time with In-Ovation self-ligating brackets compared to both Damon 2 and Smart Clip brackets observed in our study may be during the space closure and finishing stages of treatment as suggested by Harradine.

The reason for the increased treatment time with the In-Ovation brackets in later stages of treatment may be due to the higher frictional resistance to sliding reported with the active self-ligating brackets compared to passive.

Thomas, Pizzoni have shown that the passive SLBs have consistently less friction during sliding mechanics than active SLBs, with the exception of undersized round wires thereby increasing treatment time in later stages as shown by the results of our study. Henao and Kusy in their study had shown that when there is clearance, frictional force is negligible for a passive SLB coupled to any size of archwire and for an active SLB coupled to an archwire that does not contact the clip. Without clearance and when the archwire contacts the clip or slide because of the size or the geometric position of the archwire in the bracket slot, frictional force of the passive SLB was lower than the active SLB.

Tae-Kyung Kim et al have also shown that the frictional Force (FF) is negligible for passive SLB coupled to any size archwire as the slide of the passive SLB did not change the lumen size of the bracket slot when it is closed. However, the clip of the active SLB could reduce the slot depth and eventually the dimension when it is closed there by increasing the frictional resistance when larger wires are used during the later stages of treatment.

Thorstenson and Kusy explained the level of resistance to sliding of SLBs and conventional brackets in various angulations in terms of the contact angle between the bracket slot and the archwire. They concluded that, although the rate of binding as a function of relative angulation was similar regardless of bracket design, brackets with passive slides exhibited the lowest resistance to sliding. Harradine also described this clearance problem between the active clip or passive slide and the wire size in detail.

Voudouris compared friction produced by passive and active SLB and concluded that active SLB showed 216 times higher friction of ligation and SLB with active clip produced significant friction of ligation when the spring clip produces a normal force on larger diameter wire.

All the studies mentioned above support our finding of a greater treatment time with In-Ovation brackets as compared to Smart Clip and Damon 2 brackets.

All appointments of patients were recorded from the date of first placement of wire to debonding. The Smart Clip patients required the least no. of appointments followed by the Damon 2 group. The In-Ovation patients required the maximum appointments. However, this difference between the three groups was not statistically significant.
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The less number of appointments for Smart Clip patients than Damon 2 and In-Ovation brackets may be because the treatment completed earlier for the Smart Clip group. The number of appointments were proportional to the treatment time because the once a month or 4 weekly appointment schedule was followed. This is likely to change as an operator gains experience because there is no reactivation or religation required in case of the SLBs once the wire is seated into the slot. Hence, this criterion was not realistically assessed. It can also be inferred that the no. of appointments will decrease in the hands of an experienced operator once familiar with the working of the SLBs.

**Treatment Effectiveness**

The study evaluated the dental relationships at the end of orthodontic treatment by comparing the total ABO scores to determine whether treatment outcomes were different for the three groups. The study also compared the contribution of each of the eight components of the OGS to the total OGS score.

The differences in mean ABO scores between the three groups were not statistically significant. This shows that all the 3 bracket systems show similar quality of orthodontic treatment. All three bracket systems in this study showed average ABO scores in the range of 26 to 27.5 suggesting that the results were of acceptable quality, however not superior.

The lowest average score for all groups was that for interproximal contacts. This result agrees with the ABO field test in which spacing was not generally found to be a major problem.

In Smart Clip and In-Ovation groups, the marginal ridges were found to be more deficient than the other ABO criteria. This deficiency of In-Ovation brackets can be explained by the fact that the design is unfamiliar leading to unperceived errors at the time of bracket positioning thus affecting the final marginal ridge positioning. However, the same explanation does not hold good for Smart Clip brackets as their design is familiar and similar to the conventional twin brackets facilitating better bracket positioning than the Damon 2 and In-Ovation bracket systems. Hence, this study does not support this general view.

The most deficient ABO component in the Damon 2 group was found to be in the alignment. The reason for this may be explained by the fact that the Damon 2 bracket is a single wing bracket with an unfamiliar design. Rotational control and hence alignment is more efficient with twin brackets like the In-Ovation and Smart Clip brackets. Also In-Ovation brackets are active SLBs which are more efficient for initial alignment especially with larger wires.

The prescription of the three brackets was different, but no difference in final finished occlusion was found as a result of this difference.

Another factor that may influence the final treatment outcome was the torque expression of the three bracket systems. Badawi et al. have shown that the active SLBs are more effective in torque expression which is a direct result of their active clip forcing the wire into the bracket slot and the amount of archwire bracket slop is considerably less for active than passive SLBs. However, in our study, no difference in treatment outcome was noted as a result of difference in torque expression between the three bracket systems.

**Limitations**

Although occlusal indexes like the ABO index are quick, valid and accurate methods for assessing orthodontic treatment results, they measure only one aspect of orthodontic treatment outcome. Changes in facial profile, improved skeletal balance, and function were not measured in this study. The inclusion of these important parameters would greatly improve the studies on orthodontic treatment outcome. The patient records included in this study were taken from the postgraduate student program of the institute and all the cases were directly bonded. Hence, operator variations and the limited skill of the operators could be instrumental in producing deficient ABO scores in this study.

Though the results of this study showed no significant difference in the treatment time, number of appointments and ABO scores with all the three bracket systems, implication of these results as such on general population should be done with a caution because the number of subjects were less in each group.

**CONCLUSION**

The present study evaluated and compared the treatment time, number of appointments and the final orthodontic treatment outcome (ABO scores) for the three bracket systems.

- The results showed a clinically significant reduction in treatment time and number of appointments with Smart Clip as compared to In-Ovation self-ligating brackets. The result was however, not statistically significant.
- There was no clinical and statistically significant difference in treatment time and number of appointments with Smart Clip and Damon 2 self-ligating bracket systems.
- There was a reduction in treatment time and number of appointments with Damon 2 as compared with In-Ovation self-ligating bracket system but the difference was not statistically significant.
- All the three bracket systems showed similar quality of orthodontic treatment outcome. The difference in mean ABO scores between the three groups was not statistically significant. However, the Damon two group had significant discrepancy in the alignment criterion of ABO grading system than the other two groups and the difference was statistically significant. Thus, it can be concluded that Smart Clip and Damon 2 self-ligating brackets were more efficient in reducing the treatment time and number of appointments than the In-Ovation self-ligating brackets, but the difference was not statistically significant.
significant and the quality of orthodontic treatment outcome was similar in all the three groups.

REFERENCES


