Treatment efficiency of conventional vs self-ligating brackets: Effects of archwire size and material

Nicholas R. Turnbull and David J. Birnie
Portsmouth, Hampshire, United Kingdom

Introduction: In this prospective clinical study, we assessed the relative speed of archwire changes, comparing self-ligating brackets with conventional elastomeric ligation methods, and further assessed this in relation to the stage of orthodontic treatment represented by different wire sizes and types. Methods: The time taken to remove and ligate archwires for 131 consecutive patients treated with either self-ligating or conventional brackets was prospectively assessed. The study was carried out in the orthodontic department of a district general hospital in the United Kingdom. The main outcome measure was the time to remove or place elastomeric ligatures or open/close self-ligating brackets for 2 matched groups of fixed appliance patients: Damon2 self-ligating bracket (SDS Ormco, Orange, Calif) and a conventional mini-twin bracket (Orthos, SDS Ormco). The relative effects of various wire sizes and materials on ligation times were investigated. The study was carried out by 1 operator experienced in the use of self-ligating and conventional brackets.

Results: The Damon2 self-ligating system had a significantly shorter mean archwire ligation time for both placing (P < .001) and removing (P < .01) wires compared with the conventional elastomeric system. Ligation of an archwire was approximately twice as quick with the self-ligating system. Opening a Damon slide was on average 1 second quicker per bracket than removing an elastic from the mini-twin brackets, and closing a slide was 2 seconds faster per bracket. This difference in ligation time between the Damon2 and the conventional mini-twin brackets became more marked for larger wire sizes used in later treatment stages.

Conclusions: The type of bracket and the size of wire used are statistically significant predictors for speed of ligation and chairside time. The self-ligating system offered quicker and arguably more efficient wire removal and placement for most orthodontic treatment stages. (Am J Orthod Dentofacial Orthop 2007;131: 395-99)
the advantages and disadvantages of SL brackets with passive or active clips. A special tool (Damon plier) is used to open and close the D2 slide mechanism.

The time taken to open or close the D2 slides or remove or replace ligatures on the Orthos bracket was measured for 140 D2 bonded arches compared with 122 mini-twin bonded arches. This was performed by 1 operator (N.R.T.) with significant experience with both the D2 bracket and the Orthos (current practice, 60% D2 and 40% Orthos). Consecutive patients who fulfilled the following criteria were included in the study:

- Scheduled for maxillary and mandibular fixed appliances,
- Agreed to take part in the study,
- Age between 11 and 18 years,
- Due for archwire changes at the assessment visit.

Patients with cleft lip and palate, severe skeletal dysgnathia, and ectopic canines were excluded because they were to likely represent unusual outliers in time taken to manipulate archwires.

Times were recorded with a stopwatch, with the clinician working at a normal rate. A specially designed proforma recorded sex, age, extraction or nonextraction, time taken to remove or place archwire, arch (maxillary or mandibular), number of brackets engaged, number of tubes or bands engaged, and wire size and material.

The patients represented a balance in terms of extraction and nonextraction in each group. In most patients, the second molars had already been bonded. Because the clinician had a wide spread of patients in treatment, it was possible to record ligation times at various stages of treatment progress so that the full range of wire sizes was assessed. For statistical analysis, the archwires used were divided into 4 main groups based on wire size and material (Table I).

To standardize the study as much as possible, a careful protocol was followed. The time required to remove or place auxiliaries such as power chain was not included in the total time recorded.

**Table I.** Four archwire groups used in study, based on wire size and material

<table>
<thead>
<tr>
<th>Wire group</th>
<th>Wire type</th>
<th>Wire sizes (× 1000 in)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Round nickel-titanium</td>
<td>14, 16, 18</td>
</tr>
<tr>
<td>2</td>
<td>Small rectangular nickel-titanium</td>
<td>14 × 25, 16 × 25, 16 × 22</td>
</tr>
<tr>
<td>3</td>
<td>Large rectangular nickel-titanium</td>
<td>18 × 25, 19 × 25</td>
</tr>
<tr>
<td>4</td>
<td>Rectangular stainless steel</td>
<td>18 × 25, 19 × 25</td>
</tr>
</tbody>
</table>

Elastics and metal tie ligatures were not used. All slides for the D2 brackets were opened to site the archwire (the wires were not pushed through the closed premolar brackets as is occasionally possible with the system).

**Statistical analysis**

The statistical evaluation of the data included analysis of variance (ANOVA), t test, and 95% confidence intervals (CI) for difference of the means. The statistical software package used was Stats Direct Ltd (Sale, Cheshire, United Kingdom).

**RESULTS**

The 2 patient groups (D2 and Orthos) demonstrated good demographic matching; girls represented 56% of D2 group and 59% of the Orthos group. The mean ages were 13.7 years for the D2 group and 14.4 years for the Orthos group. The ratios of extraction to nonextraction patients were 39% extraction for the D2 group and 43% extraction for the Orthos group.

The time taken for ligating or removing wires was expressed as mean units of time (seconds) per bonded arch and per bracket. Overall, it was quicker to remove wires than to replace them. This was evident with both bracket types, but much more significant in the Orthos patients; the mean wire removal time for the Orthos brackets was 64.5 seconds per bonded arch (SD ± 18), compared with 98.4 seconds (SD ± 24) for wire placement. A smaller difference was observed for the D2 brackets (Table II).

When the different wire sizes were combined, the mean time to open slides for the D2 patients per bracket was 3.7 seconds compared with 4.7 seconds for elastic ligature removal with the Orthos brackets (Table II). This difference of 1 second per bracket was statistically significant when comparing the 2 groups as a whole (P < .01). The 95% CI for the difference between the per-bracket means was 0.28-1.77. Assessment of the effect of the 4 wire subgroups also showed significant differences in time taken for archwire removal between the D2 and Orthos brackets. The greatest difference was found for larger wire sizes; it took a mean time of

![Fig 1. D2 SL brackets.](image-url)
1.6 seconds longer per bracket to remove elastic ligatures compared with opening the D2 slides for wire group 4 (Table III). The smallest nickel-titanium wires (group 1) had a small difference in wire removal time between the 2 bracket types, but this was not statistically significant. There was no difference in time taken for removing maxillary vs mandibular archwires for either the D2 or the Orthos patients.

When closing the D2 slides, the mean time per bracket was 5.7 seconds, compared with 7.6 seconds for Orthos ligation (P < .001). The mean ligation times were 46.3 seconds (SD ± 22) for a fully bonded arch for D2 and 98.4 seconds (SD ± 24) for the Orthos brackets. Unpaired t tests showed these differences to be highly statistically significant (t = 3.55; P < .001) when comparing the 2 bracket types as a whole (Table II). The 95% CI for the difference between the means was −20.3 to −5.8. The CI value does not include zero, which indicates a true difference in the mean ligation times between the 2 bracket systems. For closing slides/religating elastics (ligating wires), the type of archwire had a significant effect. The D2 brackets had shorter ligation times for all wire groups and were statistically significant for wire groups 2, 3, and 4 (Table III). This is clearly illustrated in Figure 2 by the separation of the plotted lines for the 2 bracket systems. It also shows that the relative differences in ligation times are more marked for the larger wire sizes in both nickel-titanium and stainless steel.

Comparison of the maxillary arch with the mandibular arch showed no difference in wire ligation times for the Orthos brackets for any wire size. However, in the D2 group, the ligation time (placing wires) was significantly slower in the mandibular arch for wire group 1 (small round nickel-titanium). The mean times to ligate a round nickel-titanium wire per bracket were 9.1 seconds in the mandibular arch and 6.5 seconds in the maxillary arch. However, this was only marginally statistically significant (P = .041).

### Table II. Mean wire removal and ligation times in seconds (SD) per bonded arch and per bracket for all wire size groups combined for D2 vs Orthos brackets. Wire removal represents opening D2 slides or removal of elastomeric rings, wire ligation represents closing D2 slides or replacing new elastic rings

<table>
<thead>
<tr>
<th>Arch</th>
<th>Bracket</th>
<th>Arch</th>
<th>Bracket</th>
<th>Difference</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>D2</td>
<td></td>
<td>Orthos</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wire removal</td>
<td>39.8 (13)</td>
<td>3.7 (1.1)</td>
<td>64.5 (18)</td>
<td>4.7 (0.9)</td>
<td>24.7</td>
</tr>
<tr>
<td>Wire ligation</td>
<td>46.3 (22)</td>
<td>5.7 (2.3)</td>
<td>98.4 (24)</td>
<td>7.6 (1.2)</td>
<td>52.1</td>
</tr>
</tbody>
</table>

*Means different at P < .01; †means different at P < .001.

### Table III. Mean times (seconds) for wire removal or ligation per bracket for different wire sizes (see Table I for wire sizes), wire removal represents opening D2 slides or removal of elastomeric rings, wire ligation represents closing D2 slides or replacing new elastic rings

<table>
<thead>
<tr>
<th>Wire group</th>
<th>Mean time per bracket</th>
<th>Mean time per bracket</th>
<th>Difference</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wire removal</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>3.8 (n = 38)</td>
<td>4.2 (n = 31)</td>
<td>0.4</td>
<td>NS</td>
</tr>
<tr>
<td>2</td>
<td>3.9 (n = 31)</td>
<td>4.9 (n = 33)</td>
<td>1.0</td>
<td>*</td>
</tr>
<tr>
<td>3</td>
<td>3.6 (n = 39)</td>
<td>4.8 (n = 30)</td>
<td>1.2</td>
<td>†</td>
</tr>
<tr>
<td>4</td>
<td>3.6 (n = 32)</td>
<td>5.2 (n = 28)</td>
<td>1.6</td>
<td>†</td>
</tr>
<tr>
<td>Wire ligation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>7.8 (n = 38)</td>
<td>8.7 (n = 31)</td>
<td>0.9</td>
<td>NS</td>
</tr>
<tr>
<td>2</td>
<td>6.5 (n = 31)</td>
<td>8.2 (n = 33)</td>
<td>1.7</td>
<td>†</td>
</tr>
<tr>
<td>3</td>
<td>4.4 (n = 39)</td>
<td>7.1 (n = 30)</td>
<td>2.7</td>
<td>‡</td>
</tr>
<tr>
<td>4</td>
<td>4.1 (n = 32)</td>
<td>6.4 (n = 28)</td>
<td>2.3</td>
<td>‡</td>
</tr>
</tbody>
</table>

NS, no significant difference; *means different at P < .05; †means different at P < .01; ‡means different at P < .001.

Fig 2. Interaction plot of 4 wire groups for time taken to close slides/replace ligatures (mean time per bracket in seconds); note clear separation of 2 time lines for Orthos and D2 brackets, showing relatively greater difference as wire size increases (see Table I for wire group details).
DISCUSSION

The time taken to remove or ligate orthodontic wires is of interest but is a less significant characteristic of SL systems when compared with secure ligation and the possibility of lower friction/force generation. Nevertheless, the ergonomics of archwire manipulation in a busy clinical environment is important.

For both the D2 and Orthos brackets, it was quicker to remove wires than to replace them. However, Maijer and Smith found the opposite using the Activa SL bracket (“A” Company, San Diego, Calif), which had a slightly quicker ligation time. A common initial finding with the D2 bracket is difficulty in opening the slides—a time-consuming wire removal process—whereas closing slides is relatively simple. It is possible that the Activa bracket also had similar time-consuming opening characteristics. However, our study suggests that wire removal is slightly quicker than placement for both bracket types. This is most likely due to the experience and comfort zone of the operator in D2 slide manipulation. Use of 1 operator removed the potential interoperator variability in experience levels with the 2 bracket systems. To compare like with like, the operator needed to be at least as comfortable with the D2 bracket as the Orthos bracket. This allowed isolation of bracket type as the determinant of outcome rather than variation in clinical experience. A follow-up study will assess effects of the clinical experience on ligation time by comparing dental students, postgraduate trainees, and established specialists.

The ligation times show mean savings of 2 seconds per bracket for closing slides with the D2 system, and 1 second per bracket for opening slides when compared with the Orthos elastics. These time savings are more significant than those reported by Harradine. The mean time for wire placement in a fully bonded arch with the D2 system was 46 seconds compared with 98 seconds for the Orthos brackets. The difference between the 2 bracket types was statistically significant for both placing and removing wires, but is this clinically significant?

It took approximately twice as long to ligate a wire by using the elastics and Orthos brackets compared with the D2 system. The average time saved with the D2 was about 1.3 minutes per visit. This is approximately a 10% time saving in an average wire adjustment appointment. In the United Kingdom’s National Health Service, a 10 to 15 minute archwire change appointment is commonly allocated as standard. If the time is extended to a full day, a 10% saving could free up an extra 45 to 60 minutes of clinical time. This could be used to reinforce oral hygiene measures, discuss treatment progress, or generally enhance patient or parent relationships through improved communication.

The D2 brackets offer relatively greater time savings for larger wire sizes. This can be seen clearly in Figure 2, which represents the mean ligation times of the 4 wire-size groups. The 2 lines plotted on the chart diverge as wire sizes increase, indicating less time to ligate wires with both bracket types, but proportionally a greater drop in ligation time for the D2 system. Therefore, time-saving efficiencies appear to be relatively greater for the D2 brackets at later treatment stages, associated with larger wires when alignment of the teeth has progressed. This is explained by the Damon treatment philosophy, which stresses full engagement of all teeth at the earliest stage. Therefore, it will take relatively more time to fully engage light nickel-titanium archwires in all teeth with the D2 system compared with bypassing selected teeth with a conventional elastomeric appliance. Similarly, the difference in ligation time for the maxillary vs the mandibular arch was found to be significant only in the D2 group and only for small round nickel-titanium wires (initial alignment). It was statistically significantly quicker to ligate a wire in the maxillary arch in this group. This is most likely due to the generally more severe crowding in the mandibular arch, smaller inter-bracket distances in the mandibular incisor region, and attempts to initially fully ligate all teeth with the D2 system.

The decreased reliance on assistant support with SL brackets produces hidden efficiency savings, which are potentially greater for orthodontic therapists who generally do not have chairside support from dental assistants; this is required for speedy and efficient elastic ligation. Chairside time savings are welcome, but other advantages of SL systems, such as decreased treatment duration, and absence of bio-hostable elastic modules are probably more important. However, an understated advantage is the absence of the need for passing, placing, and removing elastomeric rings—a labor-intensive, tedious, and ergonomically unsatisfactory process.

SL brackets are more expensive than most conventional brackets, but this cost can be offset by the reductions in chairside time and treatment duration. There is also the small financial saving related to elastomeric rings that are obviously not required.

The D2 bracket is not difficult to open and close, but it requires a sustained learning period to become comfortable and skilled in manipulation of the bracket slide. There are more new brackets on the market with modified and novel SL mechanisms. Some of these will
probably be more efficient than others. In this study, we compared the D2 bracket with the Orthos design. The Orthos was used because it approximates the size of the D2 bracket and because larger size standard/regular twin brackets are less commonly used in the United Kingdom. It is theoretically possible that wing size could affect elastomeric ligation time, with smaller wings more difficult to ligate. Therefore, the time savings found in this study relate to a comparison with mini-twin brackets.

CONCLUSIONS

The D2 SL brackets had significantly quicker mean archwire ligation times for both placing and removing wires compared with the conventional Orthos system. Ligation of wires was twice as quick with the D2 system. The average time savings was almost 1.5 minutes of clinical activity per patient contact. In terms of clinical time, SL brackets are more efficient for most wire sizes and therefore at most stages of orthodontic treatment. However, the improvement in ligation time became more marked and statistically significant for the larger archwire sizes used later in treatment. Therefore, both the type of bracket and the size of the wire appear to be significant predictors for speed of ligation and chairside time.

We thank Bernie Higgins, Portsmouth Institute of Medicine, Health and Social Care, University of Portsmouth, for help with statistics.

REFERENCES