Self-ligating vs conventional brackets in the treatment of mandibular crowding:
A prospective clinical trial of treatment duration and dental effects

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Introduction: The aim of this study was to investigate the duration of mandibular-crowding alleviation with self-ligating brackets compared with conventional appliances and the accompanying dental effects.

Methods: Fifty-four subjects were selected from a pool of patients satisfying the following inclusion criteria: nonextraction treatment in the mandibular or maxillary arches; eruption of all mandibular teeth; no spaces in the mandibular arch; irregularity index greater than 2 in the mandibular arch; and no therapeutic intervention planned with any extraoral or intraoral appliance. The patients were randomly assigned to 2 groups: 1 group received treatment with a self-ligating bracket (Damon 2, Ormco, Glendora, Calif) and the other with a conventional edgewise appliance (Microarch, GAC, Central Islip, NY), both with 0.022-in slots. The irregularity index of the mandibular arch was normalized between the groups, and the time to alignment was estimated in days. Treatment duration was assessed by data modeling with the Cox proportional hazard regression. Lateral cephalometric radiographs were used to assess the alteration of mandibular incisor position before and after alignment. Measurements of intercanine and intermolar widths were also made on dental casts to determine changes associated with correction.

Results and Conclusions: Overall, no difference in the time required to correct mandibular crowding with Damon 2 and conventional brackets was observed. For moderate crowding (irregularity index ≤5), however, the self-ligating group had 2.7 times faster correction. This difference was marginally insignificant for subjects with irregularity index scores greater than 5. Greater crowding prolonged treatment by an additional 20% for each irregularity index unit. Increases in intercanine and intermolar widths associated with crowding correction regardless of bracket group were noted. The self-ligating group showed a statistically greater intermolar width increase than the conventional group. Also, an alignment-induced increase in the proclination of the mandibular incisors was observed for both bracket groups, but no difference was found between Damon 2 and conventional brackets for this parameter. (Am J Orthod Dentofacial Orthop 2007;132:208-15)
friction variants have not been explored systematically in clinical setups, and root resorption has not been found to vary between self-ligating and conventional brackets. Whereas ligation, especially with stainless steel ligatures, might increase friction, the effect of this variable remains unknown in vivo. A clinical trial demonstrated that the use of archwires with different surface roughnesses and, consequently different friction variants, in vitro was not accompanied by different tooth movement rates. This effect probably relates to various clinical variables that cannot be simulated in currently available laboratory configurations, including the following.

1. The rate of sliding movement has typically been chosen arbitrarily, resulting in a nonstandardized parameter that makes comparison of the results from various studies impossible. Nonetheless, when a standard rate is chosen, fundamental discrepancies between the clinical situation and the research environment arise. Therefore, the use of movement rates described by simple first-order kinetics is inappropriate.

2. Kusy and Whitley noted a dependence of friction on the velocity at which the surfaces slide past each other, an effect that has not been considered in related research.

3. Observations of the structure and morphology of retrieved nickel-titanium (Ni-Ti) archwires provided proof of calcified protein integuments, a variable not incorporated into in-vitro studies. Thus, the efficacy of treatment with these appliances relative to conventional brackets requires further study.

The purpose of this study was compare the time required to complete the alignment of crowded mandibular anterior teeth (canine to canine) with a conventional edgewise and self-ligating brackets. Additionally, the effects of alleviation of crowding on mandibular incisor inclination and intercanine and intermolar widths were investigated cephalometrically and through dental cast analysis, respectively.

**MATERIAL AND METHODS**

Fifty-four subjects were included in the study. They were selected from a large pool of patients based on the following inclusion criteria: nonextraction treatment on the mandibular or maxillary arches, eruption of all mandibular teeth, no spaces in the mandibular arch, mandibular irregularity index greater than 2; and no therapeutic intervention planned involving intermaxillary or other intraoral or extraoral appliances including elastics, lip bumpers, maxillary expansion appliances, or headgear. The demographics of these subjects are listed in **Table I**. Complete records were obtained including cephalometric and panoramic radiographs taken with the same machine (Orthophos 10, Sirona Dental Systems, GmbH, Bensheim, Germany) by the same operator (N.P.); digital extraoral and intraoral photographs and plaster models were prepared from alginate impressions.

**Table I. Demographics and clinical characteristics of sample**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Total (n = 54)</th>
<th>Conventional (n = 27)</th>
<th>Self-ligating (n = 27)</th>
<th>P value*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>mean or %</td>
<td>mean or %</td>
<td>mean or %</td>
<td></td>
</tr>
<tr>
<td>Age (y)</td>
<td>13.70</td>
<td>13.92</td>
<td>13.48</td>
<td>NS</td>
</tr>
<tr>
<td>Sex (%)</td>
<td></td>
<td>1.38</td>
<td>1.43</td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>20.37</td>
<td>25.93</td>
<td>14.81</td>
<td>NS</td>
</tr>
<tr>
<td>Female</td>
<td>79.63</td>
<td>74.07</td>
<td>85.19</td>
<td></td>
</tr>
<tr>
<td>Crowding (irregularity index)</td>
<td>5.43</td>
<td>5.37</td>
<td>5.50</td>
<td>NS</td>
</tr>
<tr>
<td>Crowding (%)</td>
<td></td>
<td>2.27</td>
<td>2.41</td>
<td>2.16</td>
</tr>
<tr>
<td>Moderate</td>
<td>52.00</td>
<td>52.00</td>
<td>52.00</td>
<td>NS</td>
</tr>
<tr>
<td>Severe</td>
<td>48.00</td>
<td>48.00</td>
<td>48.00</td>
<td></td>
</tr>
<tr>
<td>Angle class (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>59.26</td>
<td>66.67</td>
<td>51.85</td>
<td>NS†</td>
</tr>
<tr>
<td>II</td>
<td>37.04</td>
<td>33.33</td>
<td>40.74</td>
<td></td>
</tr>
<tr>
<td>III</td>
<td>3.70</td>
<td>0.00</td>
<td>7.41</td>
<td></td>
</tr>
</tbody>
</table>

NS, Not significant.
*P value for comparison of group means by t test or differences in proportions by chi-square test.
†Investigation of the significance for Angle classification variable relates to differences in distribution of Classes I, II, and III in bracket groups and not to the actual percentages of these classifications.
by their manufacturers as $-1^\circ$ for the conventional and $-6^\circ$ for the self-ligating. All first and second molars (when present) were bonded with bondable tubes. Bracket bonding, archwire placement, and treatment were performed by the same clinician (N.P.) who has received training for, and routinely uses, both appliance systems.

The amount of crowding of the mandibular anterior dentition was assessed by using Little’s irregularity index.\(^\text{15}\) Measurements were made on the initial casts by the same clinician using a fine-tip digital caliper (Digimatic NTD12-6°C, Mitutoyo Corp, Kanagawa, Japan), and all values were entered automatically into an Excel spreadsheet by using the IT-012U input tool (Microsoft, Redmond, Wash) interfaced with the caliper. Similarly, the irregularity index values of patients were recorded and normalized in each bracket group to investigate the effect of bracket type on treatment duration at various crowding levels.

The archwire sequence for the conventional group was in most cases 0.016-in copper-Ni-Ti (Cu-Ni-Ti) 35°C (Ormco) ligated mainly with elastics, followed by a 0.020-in medium Sentalloy archwire (GAC) ligated with elastics. To correct rotations, elastics were often placed in figure-8 form.

In the self-ligating group, the archwire sequence involved a 0.014-in Cu-Ni-Ti Damon (Ormco) and 0.014 × 0.025-in Cu-Ni-Ti Damon (Ormco). The difference in archwire sequence was due to the mechanical-therapeutical scheme suggested by the relevant guidelines in the Damon 2 bracket manual.\(^\text{16}\)

The date (T1) that the each patient was bonded was recorded, and all patients were followed monthly. Complete alleviation of crowding was judged clinically by the same practitioner. Upon visual inspection of correction of proximal contacts, the patient was considered complete, and the alignment date (T2) was determined and recorded on the spreadsheet. Only the alignment of the 6 mandibular anterior teeth was evaluated. In other words, a patient was considered to have reached T2 if the 6 mandibular anterior teeth were aligned, regardless of possible irregularities in the posterior segments. The time to alignment (T2 – T1) for each patient was calculated in days. At T2, a cephalometric radiograph, an alginate impression for model construction, and digital photographs of the mandibular arch were taken, and treatment was resumed in both arches.

Changes in intercanine and intermolar widths were recorded from dental casts taken at T1 and T2. Measurements, made with a digital caliper (Mitutoyo), included the distance of the cusp tips in the canines and the central groove in the molars.

### Table II. Mean treatment time to alignment by bracket system and severity of crowding

<table>
<thead>
<tr>
<th>Bracket</th>
<th>n</th>
<th>Mean time to alignment (days)</th>
<th>SD</th>
<th>P value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional</td>
<td>27</td>
<td>114.51</td>
<td>46.44</td>
<td></td>
</tr>
<tr>
<td>Self-ligating</td>
<td>27</td>
<td>91.03</td>
<td>31.94</td>
<td>NS (.06)</td>
</tr>
<tr>
<td>Crowding</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moderate</td>
<td>28</td>
<td>89.46</td>
<td>31.46</td>
<td>&lt;.05</td>
</tr>
<tr>
<td>Severe</td>
<td>26</td>
<td>117.11</td>
<td>46.05</td>
<td></td>
</tr>
</tbody>
</table>

NS. Not significant.

*P value based on log-rank test for equality of survivor functions.

Lateral cephalograms were traced by the same person (N.P.), and mandibular incisor position and inclination were assessed for all patients by using the following angular measurements at T1 and T2: mandibular incisor to mandibular plane, mandibular incisor to nasion-Point B line, and mandibular incisor to Point A-pogonion line.

To assess intraexaminer reliability, 8 plaster models and 8 cephalometric radiographs were randomly selected from records. The cephalometric radiographs were retraced, and the measurements of the cephalometric variables were repeated; in the dental casts, the intercanine and intermolar widths were remeasured. The reproducibility of the measurements was investigated with paired t tests for each variable. The analysis showed no statistical significance between the first and second measurements ($P = .002$).

### Statistical analysis

Demographic, clinical, and cephalometric characteristics were investigated with conventional descriptive statistics. Comparisons between the 2 appliance groups were conducted with the t test or the chi-square test, depending on the characteristic’s nature (numerical or categorical). Treatment duration—the time required to resolve crowding—in both appliance groups was investigated with statistical methods for survival analysis, whereas alignment rate ratios for appliance type and crowding level were studied with the Cox proportional hazard regression. All analyses were conducted with the Stata 8 statistical package (StataCorp, College Station, Tex).

### RESULTS

Table I gives the demographic variables of the groups including age, sex, and irregularity index. Angle classification distribution showed no difference between the 2 groups; there was no discrimination with respect to age, sex, and irregularity index between the
2 samples, thus validating the random assignment of appliances to each group.

In Table II, the results of treatment time to alignment are shown for the bracket groups. A marginal lack of statistical significance was shown for the self-ligating group, whereas crowding was shown to statistically alter treatment time. This prompted further data analysis by hazard ratios shown in Table III; this indicated that analysis of data by irregularity index seemed to produce a higher alignment rate for the self-ligating group. Specifically, patients with moderate crowding (irregularity index <5) were finished 2.7 times faster than those treated with conventional brackets (P <.05). Severe crowding showed a similar but less powerful tendency; treatment time was 1.37 times faster compared with conventional brackets, but this effect did not reach statistical significance.

In Table IV, intercanine and intermolar width changes are shown, suggesting that the correction of crowding in both cases produced a small but statistically significant expansion in the mandibular arch. Intercanine width seemed to show no change between bracket groups, whereas intermolar width increased about 2 mm in the self-ligating group compared with 0.5 for the conventional bracket group (P <.05).

Table V lists the results of the assessment of mandibular incisor position in response to alleviation of crowding.
Treatment resulted in an overall significant proclination of the mandibular incisors regardless of bracket type, whereas no difference for incisor position between bracket groups was identified.

Representative intraoral photographs of treatment of a low (<5) and a high (>5) irregularity index mandibular arch treated with the Damon 2 bracket are shown in Figure 1. The corresponding pictures of a subject with mandibular crowding treated with a conventional appliance are shown in Figure 2. In Figure 3, the variation of treatment time with the severity of crowding is shown: the pattern seen initially for prolonged alleviation of severe relative to moderate crowding continued during the full term of treatment.

DISCUSSION

Mandibular crowding was selected as a model for examining the efficiency of brackets because correction of this discrepancy largely depends on the “free play” or clearance of the archwire inside the slot walls. Although canine retraction with sliding mechanics is the basic scenario when free play is the dominant mechanotherapy, this model has some fundamental difficulties when a research design is considered. These include the necessity for adjustment of the rate of movement between the 2 groups, the requirement for estimation of the pre- and postmovement condition, and the assessment of the relative efficiency of the appliances. On the other hand, alleviation of crowding is a treatment process in which both initial and final stages can be quantitatively determined with the irregularity index, and measurements can be made regardless of tooth inclinations or rotations, as opposed to retracting canines, where these 2 parameters can interfere with the assessment of crown spatial orientation.

The results of this study suggest that, overall, Damon 2 brackets are not more efficient in terms of treatment time required to resolve severe anterior mandibular crowding than conventional appliances. However, moderate crowding was alleviated about 2.7 times faster with Damon 2 brackets than with conventional appliances. This difference might be because of the substantially greater free play of the self-ligating appliances, an effect that facilitates undisturbed labial movement of the crown. In contrast, elastomeric modules or steel ligatures act as obstacles because of the stress they exert on the wire adjacent to the bracket sides, precluding free sliding of the wire into the slot walls and adversely affecting movement rate. This advantage of self-ligation over conventional ligation is eliminated when crowding exceeds a certain amount and space in the arch is restricted. In the latter case, the relative efficiency of the bracket system seems to be of limited use because of difficulties that are beyond the capabilities of mechanotherapeutical configurations. Likewise, we found a positive effect of the severity of crowding on treatment duration, which was about 20% longer for
each additional irregularity index unit (hazard ratio for 1 unit of irregularity index increase: 0.81, \( P < .05 \), data not shown).

Our findings agree with previous trials that found no difference in the crowding alleviation stage at predetermined times with conventional and self-ligating SmartClip brackets (3M Unitek, Monrovia, Calif)\(^{17}\) or conventional and self-ligating Damon 2 brackets.\(^{18}\)

![Fig 2](image1.png)

**Fig 2.** Occlusal views of mandibular arches with low (<5) and high (>5) irregularity index valves treated with conventional brackets.

![Fig 3](image2.png)

**Fig 3.** Graph of variations of treatment duration with severity of crowding. Y-axis gives proportion of patients still in treatment (not aligned) at different times (days on x-axis). By drawing line perpendicular to x-axis at given time value, proportion of patients not completed for each crowding group (moderate or severe) is extrapolated from corresponding value given in y-axis. Note persistence of alignment completion pattern through entire treatment period: severe crowding has higher percentage of incomplete patients compared with moderate crowding at any treatment time.
In a similar study, Torres et al\textsuperscript{19} reported no difference in treatment duration between Damon 2 and Synergy brackets (Rocky Mountain Orthodontics, Denver, Colo) with a maxillary, split-mouth setup.

It is strikingly surprising that self-ligating brackets have been advocated and marketed long before the publication of any clinical trials investigating their efficiency by independent sources. Anecdotal evidence and case series exhibitions do not substantiate the effectiveness of a biomedical material or a new technique, and it seems that more clinical studies are required in the mainly laboratory-based assessments of orthodontic materials and techniques.

A decade after the introduction of self-ligating brackets, the literature lists just a handful of clinical studies, of which even fewer satisfy the criteria of a prospective and randomized clinical trial. Most were conducted with treatment records of more than 1 practitioner or questionnaires filled out by patients. Moreover, even the few comparative trials available involve various malocclusions treated with many methods and modalities, thus precluding a means to isolate confounding variables. This is because various treatment auxiliaries and utilities such as intermaxillary elastics, treatment variability such as extractions, and extraoral appliances introduce variables that, if not carefully weighted in both populations, can distort the results.\textsuperscript{20,21} Our study involved a thorough screening of patients with strict inclusion criteria; this improved the reliability of the outcome. Moreover, the same clinician, who has been trained and routinely uses both techniques, treated all patients, and a prospective model was used rather than recording the treatment variables from records or questionnaires. In addition, the drop-out rate of this study was nonexistent. This is important in clinical trials because patient drop-out rates distort the assumption of equal effect on both treatment groups, since exclusion of patients from the study might show a preference connected with the process or the result itself.\textsuperscript{22}

Retrospective studies include the possibility of outcome bias, because the treatment results are known before assignment of the bracket type to the patient groups. Data collection in these studies relies on the accuracy of treatment records, whereas a trial including more than 1 practice to collect enough patients has the additional complicating factors of interoperative variability in materials handling and clinical management.

In contrast to various anecdotal evidence, our findings suggest that both brackets alleviate crowding by similar mechanisms that involve mandibular incisor proclination and mild expansion of the dental arches. The former seemed unaffected by the difference between the torque-prescribed values of the 2 appliances, probably because of the relatively greater buccolingual proclination induced by lack of space. On the other hand, the use of preformed Ni-Ti archwires precludes the operator’s absolute control over the dimensions of the dental arch. Although the overall expansion of the mandibular arch of the subjects in this trial was found to be relatively small, the intermolar width gained in the self-ligating group was 1.5 mm greater than that for the conventional-appliance group. Expansion with preformed arches of 0.5 to 1 mm might be negligible and could be a spontaneous effect of treatment. However, traditional assumptions on the intentional “development of the arch,” which means substantially expanding the buccal segments, have been found to be highly unpredictable.\textsuperscript{23} The reported dental effects also partially agree with a recent report that evaluated dental-arch dimensions of nonextraction patients treated with conventional or self-ligating appliances.\textsuperscript{24} The results of that study showed that posttreatment maxillary and mandibular arch widths increased significantly in the Damon 2 bracket group.

Additional aspects of treatment with self-ligating brackets include the necessity of the clinician’s familiarity with the new materials and uses, the patient’s potential discomfort, and the probably higher failure rates of these appliances because of their greater thickness. Although the former might be a concern, the latter—that the thick bracket induces larger moments during mastication and might result in debonding—has not been proven valid.\textsuperscript{25}

CONCLUSIONS

The results of this clinical trial suggest the following conclusions.

1. There was no difference in the time required to correct mandibular crowding between self-ligating Damon 2 and conventional edgewise brackets. However, when moderate and severe crowding were examined separately, self-ligating brackets corrected moderate crowding (irregularity index $<5$) 2.7 times faster than conventional appliances. This difference was insignificant for subjects with severe crowding (irregularity index $>5$).

2. Overall, greater crowding prolonged treatment by 20% per irregularity index unit, regardless of bracket type used.

3. Overall increases in intercanine and intermolar widths were associated with crowding correction in both bracket groups; Damon 2 brackets resulted in statistically greater intermolar width increases than conventional appliances.
4. There was an overall increase in the proclination of the mandibular incisors associated with crowding correction in both bracket groups; no difference was identified between Damon 2 and conventional brackets for this parameter.

REFERENCES