A Retrospective Investigation of the Effects and Efficiency of Self-ligating and Conventional Brackets

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ABSTRACT

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Introduction: Marketing strategies for self-ligating brackets have focused on less need for extractions and faster treatment. Recent meta-analyses have not found these claims to be well supported, but they point out limitations of the current evidence. These meta-analyses also conclude that additional, well-designed studies are indicated to improve our evidence base. The purpose of this retrospective cohort study is to assess the effects and efficiency of treatment with self-ligating brackets compared to conventional brackets. A secondary purpose is to identify any pretreatment malocclusion characteristics associated with choice of either self-ligating or conventional brackets. **Methods:** Patients treated in the private offices of two practitioners who simultaneously used both self-ligating and conventional brackets were selected for this study. The self-ligating subjects were selected first, and for each subject, an age and gender matched subject was chosen from the respective office. The self-ligation subjects were consecutively treated adolescents and young adults (11-25 years-old) who completed comprehensive fixed appliance therapy between January 1, 2011 and April 31, 2012. Patients with craniofacial anomalies, surgical treatment, treatment with arch expansion using expanders, interdisciplinary treatment, and incomplete records were excluded. The outcome measures were changes in the intercanine width, intermolar width, and arch length for both arches, change in mandibular incisor inclination, final PAR score, percent PAR reduction, overall treatment time, total number of visits, number of emergencies, number of broken brackets, and other emergencies such as a wire sliding to one side or the loss of ligation. All measurements were performed on digital models or digital lateral cephalograms in a blinded manner. PAR scores were measured by two calibrated assessors and the average of the two scores were used. Data were analyzed using the independent sample t-test, chi-square or fisher exact test and linear regression analysis. **Results:** The final sample comprised 74 patients from Clinician 1, and 34 patients from Clinician 2. The two clinicians exhibited significant differences in treatment duration, as well as in treatment strategies, such as the use of the SureSmile technique. Therefore, the decision was made not to pool the data from the two offices. For Clinician 1, no significant differences were observed between self-ligating and conventional brackets for the outcomes described above, other than increased arch length in both arches in the self-ligating group. The self-ligation patients treated by Clinician 2 demonstrated a significant increase in transverse dimension, less percent reduction in PAR score, less treatment time, fewer visits, and more wire sliding emergencies compared to the conventional bracket group. **Conclusions:** While some significant findings were observed, the small sample and lack of consistent findings between the two clinicians makes it difficult to draw strong conclusions.

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DEDICATION

To my husband, Kunal

Introduction

The first ever self-ligating brackets was the Russell Lock edgewise attachment as described by Stolzenberg in 1935 [Stolzenberg, 1935]. Over the past several decades, many new designs have been introduced, including the Speed Bracket in 1980, the Time bracket in 1994, the Damon SL bracket in 1996, the TwinLock bracket in 1998, the Damon 2 and In-Ovation brackets in 2000, and the Damon 3 and SmartClip brackets in 2004 [Harradine, 2008]. The use of self-ligating brackets has increased over time. In 2002, 8.7% of American orthodontists used at least one self-ligating system; in 2008, the number had increased to 42% [Kiem et al., 2008].

Since the advent of self-ligating brackets, there have been assertions that self-ligating brackets are more efficient and more effective in treating malocclusions. Reduced friction with self-ligating brackets is claimed to be a great advantage over conventional brackets. It is asserted that low friction allows for sliding mechanics to be accomplished in the truest sense, thereby facilitating alignment, increasing the appointment intervals, and possibly reducing the overall treatment time [Damon, 1998; Harradine, 2008]. Also, with less friction, the idea that less force is needed to cause tooth movement has led to the presumption that self-ligating brackets produce more physiologically harmonious tooth movement by not interrupting the periodontal blood supply [Damon, 1998]. Therefore, more alveolar bone generation, greater amounts of lateral expansion, less proclination of anterior teeth, and less need for extractions are claimed to be possible with self-ligating brackets. Other advantages of the self-ligating bracket system that have been listed include more certain full archwire engagement, less chairside assistance, and faster archwire removal and ligation, leading to reduced chair time [Harradine, 2003].

The evidence regarding the amount of friction with self-ligating brackets is limited to several in-vitro studies. A systematic review that included 19 in-vitro studies concluded that self-ligating brackets produced lower friction with small round archwires in the absence of tipping and malalignment. However, there was little evidence to claim an advantage with large rectangular wires. Also, it was reported that friction in both bracket types increased as the archwire size increased [Ehsani et al., 2009]. Another important factor to consider is resistance to sliding. The resistance to sliding is a combined effect of friction, as well as elastic binding and/or notching. With a .018 x .025-in wire in a 0.022-in slot, the resistance to sliding in the second order of space was found to be lower for the self-ligating brackets compared to the conventional brackets because of a lower magnitude of friction. Additionally, due to the greater critical contact angle of self-ligating brackets, the resistance to sliding is further reduced at any angle above the critical contact angle [Thorstenson et al., 2001].

Clinical studies evaluating total treatment time have shown results in favor of both bracket types. Retrospective studies by Eberting et al. [2001] and Harradine [2001] found significantly decreased total treatment time and fewer visits with self-ligating brackets. However, a large retrospective study [Hamilton et al., 2008] and all prospective studies have found no measurable advantages in orthodontic treatment time, the number of treatment visits, and time spent in initial alignment with self-ligating brackets over conventional brackets [Miles, 2005; Miles et al., 2006; Pandis et al., 2007; Scott et al., 2008; Fleming et al., 2009; Fleming et al., 2010; DiBiase et al., 2011, Johannson et al., 2012]. Recent meta-analyses included only three retrospective studies due to significant methodological differences and found no difference in terms of reduced overall treatment time, number of visits, and efficiency of initial orthodontic alignment between self-ligating brackets and conventional brackets. These meta-analyses concluded by indicating a lack of sufficient evidence to show that orthodontic treatment is more or less efficient with self-ligating brackets [Chen et al., 2010; Fleming et al., 2010]. In spite of insufficient evidence for overall treatment time, some benefits, such as ease of ligation, and reduced chair time with the self-ligating brackets, were supported. Cross-sectional studies have shown decreased chair time with significantly shorter archwire ligation and removal times when compared with conventional brackets [Paduano et al., 2008; Turnbull et al., 2007]. The meta-analysis by Chen et al., which included these two studies, reported a mean time savings of 20 seconds per arch for self-ligation versus ligature removal.

Studies investigating arch dimensions and mandibular incisor inclination have shown no significant difference between the two groups for intercanine and intermolar widths [Ong et al., 2011; Pandis et al., 2011; Fleming et al., 2013]. Though, some studies have shown a greater increase in intermolar width with self-ligating brackets [Jiang and Fu, 2008; Scott et al., 2008; Pandis et al., 2010], their meta-analysis did not find any significant differences in the intercanine and intermolar widths between the two bracket systems [Chen et al., 2010]. For incisor proclination, a meta-analysis indicated that self-ligating brackets resulted in slightly less mandibular incisor proclination (1.5 degrees) [Chen et al., 2010]. Thus, evidence on the advantages of self-ligation appears to be mixed, and other well-conducted studies are needed to evaluate the various claims made by proponents of self-ligation.

The occlusal quality was evaluated in the meta-analysis by Chen et al. [2010], which included three studies, resulting in no significant difference at the end of treatment

[Eberting et al., 2001; Harradine, 2001; Hamilton et al., 2008]. An identical result was obtained for both treatment time and occlusal quality outcomes in the meta-analysis of these three retrospective studies, two of which were smaller studies with passive self-ligating brackets, and one larger study with active self-ligating brackets. These studies used different indices to assess the quality of occlusal finish. Thus, these results must be interpreted with caution due to heterogeneity of the measured outcomes. Some prospective studies that compared percent reduction in PAR scores have not found any significant differences between self-ligating and conventional brackets [Fleming et al., 2010; DiBiase et al., 2011].

Studies comparing the failure rate between self-ligating and conventional brackets have shown conflicting results. Pandis et al. [2006] found no significant difference between the two systems. Other studies showed higher failure rates associated with self-ligating brackets [Miles et al., 2006; Harradine 2001; Hamilton et al., 2008;]. Hamilton et al. [2008] compared active self-ligating brackets to conventional brackets and found more debonded brackets and other emergency visits in the active self-ligating bracket group. The meta-analysis could include only two of these studies with high heterogeneity and contradictory results leading to an insignificant conclusion [Chen et al., 2010].

There is still controversy and limited knowledge regarding the evidence for efficiency and efficacy of self-ligating brackets. A survey of US orthodontists with 430 respondents showed that 90% of the orthodontists currently use self-ligating brackets, or have in the past. Orthodontists' bracket preference was significantly influenced by the proportion of patients they treated with self-ligating brackets, the number of cases it took them to become accustomed to self-ligation, and the average appointment intervals for both self-ligating and conventional brackets. Conversely, practitioners preferred conventional brackets during the finishing stage of treatment. Conventional brackets were also preferred because they were more cost effective and resulted in fewer emergency appointments [Prettyman et al., 2012].

While randomized trials are the ideal method to investigate clinical questions, well-designed cohort studies may also provide valuable information. The purpose of this retrospective cohort study is to assess the effects and efficiency of treatment with self-ligating brackets over conventional brackets. A secondary purpose is to identify any pretreatment malocclusion characteristics associated with the choice of self-ligating or conventional brackets.

Materials and Methods

This retrospective cohort study was approved by the Institutional Review Board at the University of Washington. The self-ligation group (Damon Q, Ormco was used by both clinicians) included consecutively treated patients from both offices. The self-ligating subjects were selected first, and for each subject, an age and gender matched control (Mini uni-twin, 3M Unitek was used by Clinician 1 and Victory series, 3M Unitek was used by Clinician 2) was chosen from the respective office. All brackets systems were .022 slot. The orthodontic records were obtained from the private practices of two faculty members in the University of Washington's Department of Orthodontics. These practitioners had been treating roughly equal numbers of patients within their practices with conventional and self-ligating systems for the past few years. The study included adolescents and young adults (11-25 years-old) who had completed comprehensive fixed appliance therapy between January 1, 2011 and April 30, 2012. Patients who had previously received interceptive treatment or extractions were included. Any patients with craniofacial anomalies, surgical treatment, treatment with arch expansion using expanders, interdisciplinary treatment, and incomplete records were excluded.

Initial (T1) and final (T2) records consisting of digital or plaster study models, lateral cephalometric radiograph, and treatment notes were obtained from both offices. All patient identifiable information was replaced by random study ID numbers. The digital study models from one office were exported from OrthoCAD 3.5 (Align Technology, Carlstadt, NJ) to the Ortho Insight 3D software (Motion View software, LLC). Plaster models from the other practice were scanned using the Ortho Insight 3D scanner (Motion

View software, LLC). All digital or scanned lateral cephalometric radiographs were imported to Dolphin Imaging software (Patterson Dental Supply, Inc.).

The arch dimension, irregularity index as a measure of crowding, overjet, and the Angle molar classification were measured on digital models by the primary investigator (MA). The peer assessment rating (PAR) was also performed on digital models by the primary investigator and a second assessor (KJ) independently and the mean scores at the initial and final time points were used for data analysis. Both examiners were calibrated for the peer assessment rating (PAR) prior to performing the measurements for the study. The contact displacement component of the PAR score was measured using a millimeter ruler with the digital models positioned in the occlusal view. The models were enlarged and the grid overlaying the model was used for calibration. The buccal occlusion assessment was accomplished by positioning the study casts in the right or left buccal position without moving them around. The overjet, overbite and centerline were measured using a linear measurement tool available with the digital software, being careful to measure in the appropriate plane of space. The primary investigator traced all cephalograms on Dolphin Imaging software (Patterson Dental Supply, Inc.) to measure the mandibular incisor inclination. Treatment charts were reviewed in the offices by the primary investigator to determine treatment time, total number of visits during treatment, emergency visits, and reason for emergencies. All data measurements on digital models and radiographs were performed in a blinded manner. Data abstraction from treatment charts could not be blinded, as the appliance system appeared on every page of treatment notes.

The following outcomes were measured for initial (T1) and final (T2) time points.

1. Arch dimensions:
   - Intercanine width- Distance in mm between the tips of the mandibular and maxillary canines. (Fig. 1, 2)
   - Intermolar width- Distance in mm between the central grooves of the mandibular and maxillary first molars. (Fig. 3, 4)
   - Arch length- Sum of the distances of two lines from the mesial surface of the 1st molar to the contact between centrals in both mandibular and maxillary arches. (Fig. 5, 6)
2. Mandibular incisor inclination: The angle in degrees between the long axis of the most prominent mandibular incisor and the line passing through the gonion and menton (mandibular plane). (Fig. 7)
3. Final PAR score and Percent reduction in PAR scores: Measured in accordance with the peer assessment rating index (Figs. 8-11). Percent PAR reduction was calculated as follows:

   $$\text{Percent Reduction in PAR} = \frac{\text{PAR at T1} - \text{PAR at T2}}{\text{PAR at T1}} \times 100\ \%$$

4. Total treatment time: Calculated in months from the placement of fixed appliances to the time of removal.
5. Number of visits during treatment, excluding emergencies.
6. Failure rate: Number of emergency visits, including unscheduled emergencies. Reasons for emergency visits, including slid wire, broken brackets, loss of ligation due to a broken door or loose elastomeric tie was noted.
7. Pretreatment crowding: Assessed by measuring Little's incisor irregularity index [Little, 1975] in the mandibular arch.

8. Overjet: Distance in mm from the incisal edge of the maxillary incisors to the labial surface of mandibular incisors.
9. Angle's molar classification was noted.
10. Extraction rate was also recorded.

Measurement error was assessed by randomly selecting 10 study casts and lateral cephalometric radiographs using Excel (Microsoft for Mac, 2008 version). The radiographs were re-traced using Dolphin Imaging software (Patterson Dental Supply, Inc.) to determine mandibular incisor inclination in relation to mandibular plane and digital models were re-measured for intermolar width, intercanine width, arch length, and Little's incisor irregularity index. Both measurements were made two weeks apart. Dahlberg's formula ($s = \sqrt{\sum d^2 / 2n}$, where d = difference between the first and second measurements) was used to evaluate the magnitude of the error for each variable. The coefficient of reliability (CoR) was calculated as $CoR = 1 - s^2/SD^2$, where s is the Dahlberg's error and SD is the standard deviation of the difference between the initial and final measurements of intermolar and intercanine widths, arch length, and Little's incisor irregularity index. Additionally, the PAR scores were measured according to a predetermined protocol. If the examiners' measurements for PAR score differed by more than 5 points, the casts were re-scored independently. If the scores were still more than 5 points apart, the PAR score was measured by the two examiners simultaneously to achieve a consensus score.

A priori power analyses based on 80% power were conducted using the Russ-Lenth's power and sample size online calculator. For 80% power, a clinically significant mean difference was hypothesized and standard deviation estimated for treatment duration (Harradine 2001), intercanine width (Germane et al, 1991; Fleming et al, 2009), and mandibular incisor proclination (Scott et al, 2008) to achieve the required sample size (Tables 1a-c). Since all these variables were considered of equal importance to the study, it was determined that a sample size of 47 patients in each group were needed. The level of statistical significance was set at 0.05.

The data were entered into an Excel (Microsoft for Mac, 2008 version) spreadsheet and then imported into SPSS (IBM; version 19) for statistical analysis. Descriptive statistics for both bracket groups were calculated for all variables. Independent T-tests or Chi-square/ Fisher exact tests were performed for all variables to assess the difference between the self-ligating and conventional brackets without adjusting for effect modifiers or confounders. General linear regression models were created to assess the difference between the bracket types for final mandibular incisor inclination, final PAR score, percent reduction in PAR score, treatment duration, and total number of visits after adjusting for potential confounding variables such as initial incisor inclination, low torque brackets, Angle classification, initial PAR, and SureSmile treatment. Descriptive statistics using bar graphs and independent sample t-tests were used to determine if any pretreatment malocclusion traits such as crowding, initial overjet, Angle's molar classification, initial mandibular incisor inclination, and extraction rate were associated with choice of self-ligating or conventional brackets.

Results

The magnitude of error was found to be small for all measurements, and the calculated coefficients of reliability confirmed the validity of the method (Table 13). The PAR scores between the two assessors were different by more than 5 points in 37 out of 216 sets of study casts, indicating an inter-examiner reliability of 82.9%. After each of these 37 casts was independently re-scored, the scores for 15 sets of casts were still different by more than 5 points. These remaining 15 sets of study casts were scored by consensus.

A total of 122 subjects from both offices (84 from Clinician 1 and 38 from Clinician 2) were selected initially. However, both practitioners treated only about 5% of their patient population with extractions, and therefore, they were removed from the sample in order to prevent any undesirable effects on important outcome variables such as treatment duration. The final sample comprised 74 patients from Clinician 1, and 34 patients from Clinician 2. The two clinicians exhibited significant differences in treatment duration, as well as in treatment strategies, one of these being use of the SureSmile technique. Therefore, the decision was made not to pool data from the two offices.

Pretreatment demographics were similar for both groups since the samples were matched for age and gender (Table 2). For Clinician 1, there were some differences for initial mandibular incisor inclination and PAR scores between patients selected for the two bracket types, while the self-ligating and conventional samples from clinician 2 were not significantly different for all clinical factors (Table 3). Table 4 demonstrates some differences in treatment strategies between the two practitioners. Most importantly, Clinician 1 used SureSmile for some subjects, while Clinician 2 did not. The same practitioner also used low torque self-ligating brackets, which was taken into account in the linear regression model for the mandibular incisor inclination measurement.

The arch dimension in self-ligation patients exhibited a greater change in arch length (about 2 mm for both maxillary and mandibular arches) for clinician 1's sample (Table 5). In contrast, Clinician 2's self-ligation sample only showed greater changes in the transverse dimensions for both maxilla and mandible.

The mandibular incisor inclination change was not different between self-ligating and conventional bracket groups for Clinician 1 in both unadjusted and adjusted models (Table 6). For Clinician 2, however, the change in incisor inclination was less in the self-ligating group by 4.5 degrees when compared to the conventional bracket group in the unadjusted model. After adjusting for initial mandibular incisor inclination, the change in incisor inclination was not statistically significant at 3.0 degrees. Similarly, all patients were finished satisfactorily in both groups by Clinician 1. But, there was a significant difference in the unadjusted and adjusted percent PAR reduction for Clinician 2 (Table 7). The final PAR scores and percent reduction in PAR scores reflects a better finish for the patients treated with conventional brackets when compared to those treated with self-ligating brackets.

Treatment duration and total number of visits were similar for Clinician 1. SureSmile use seemed to be related to a decreased treatment time of about 3 months (18.6 months for SureSmile, and 21.4 months for those not using SureSmile treatment, p value 0.02). After adjusting for SureSmile and the initial PAR score, treatment duration (β, -0.30; 95% CI, -2.05, 1.46) and total number of visits (β, -0.45; 95% CI, -1.81, 0.91) remained statistically insignificant (Tables 8, 9). In contrast, there was a large difference in treatment duration and total number of visits for Clinician 2. The adjusted model indicates that patients treated with conventional brackets took 10.8 months longer and 7.0 more visits than those treated with self-ligating brackets. This difference is both statistically and clinically significant.

There was no difference in the failure rate between the two bracket groups for both clinicians except for more wire sliding events noticed in the self-ligating group than conventional group for Clinician 2's sample (Table 11).

Only mandibular incisor inclination was found to be associated with the choice of one bracket system over the other. Patients with more proclined incisors received conventional brackets by Clinician 1 (Table 12). There were no significant trends noted for Clinician 2. Both clinicians had a tendency to use self-ligating brackets for more crowded patients, and conventional brackets for patients with increased overjet and a Class II molar classification. However, all these trends were not statistically significant (Table 12).

Discussion

The effectiveness and efficiency of self-ligation has been in debate since its inception. This study evaluated the effect of the bracket systems on the arch dimensions, and their effectiveness based on mandibular incisor inclination, and the occlusal treatment outcome according to the peer assessment rating (PAR) index. Treatment duration and number of visits was used to assess the efficiency of these bracket systems. Additionally, the failure rate was noted for both bracket types.

The results of this study displayed a large variation between the two practitioners. This investigation showed that the self-ligation seemed to be associated with increased arch length and arch width. Previous studies have also found a greater increase in the mandibular intermolar width for the self-ligation group, although there were no differences in the intercanine width [Jiang and Fu, 2008; Fleming et al., 2009; Pandis et al., 2010]. Two of these studies, however, used differing archwire sequences and archforms similar to our study [Jiang and Fu, 2008; Pandis et al., 2010] and Fleming et al. [2009] showed an increase of only 0.91mm in intermolar width, which is clinically insignificant. There have been other studies that did not show any significant changes in arch width when comparing self-ligating brackets [Scott et al., 2008; Chen et al., 2010; Pandis et al., 2011; Fleming et al., 2013]. Scott et al. [2008] reported on extraction patients and found no change in intermolar width. They explained their finding by the forward movement of molars into a narrower segment of the arch. Prospective studies by Pandis et al. [2011] and Fleming et al. [2013] used the same archwire sequences and arch forms for all comparison groups and controlled for all possible effect modifiers in their statistical model. Thus, the positive changes observed with the intercanine and intermolar widths in our study could have possibly been produced by the use of archwires with broader archforms (Ormco) with self-ligating brackets and differing archwire sequences, like other studies that have indicated significant results. In addition, studies have shown that intermolar expansion in the maxillary arch comprises primarily of buccal tipping with self-ligating brackets and similar low friction systems, which leads us to believe that physiologic buccal expansion and alveolar bone generation is questionable [Franchi et al., 2006; Cattaneo et al., 2011].

Clinician 1 showed an increase in arch length by approximately 2mm in both arches. This practitioner treated patients who had higher initial PAR scores (largely due to more crowding) with self-ligating brackets, which could have contributed to the greater increase in arch length in the self-ligating group. Scott et al. [2008] observed no difference in arch length between the self-ligating and conventional bracket systems even though the initial incisor irregularity was higher for the conventional bracket group.

The final mandibular incisor inclination was found to be 4.5 degrees less in the self-ligation group compared to the conventional bracket group for Clinician 2's sample. However, after adjusting for the initial labiolingual inclination and Angle's molar classification, the difference was no longer significant for both clinicians (β, -3.0; 95% CI, -6.8, 0.8). Most studies have depicted mandibular incisor proclination in both groups with no statistical difference [Jiang and Fu, 2008; Scott et al., 2008; Fleming et al., 2009; Pandis et al., 2010], once again indicating that the mechanism for relieving crowding involves incisor proclination and transverse expansion through tipping of posterior teeth, which is similar for conventional and self-ligating brackets. Also, another study using CBCT to compare the labiolingual inclination of mandibular incisors relative to the occlusal plane between active and passive self-ligating brackets confirmed a significant proclination of mandibular anterior teeth, thereby rejecting the claim of torque control by self-ligating systems [Cattaneo et al., 2013]. The meta-analysis including three of these studies showed that self-ligating brackets had 1.5 degrees less proclination that was statistically significant, although it may not be a clinically significant change [Chen et al., 2010].

A potential confounder in the measurement of mandibular incisor inclination is the variation in torque built into the various bracket systems used by the clinicians. Both clinicians used the Damon Q self-ligation prescription with -3 degrees of torque for mandibular central and lateral incisors; however, they used different prescriptions for the conventional brackets. Clinician 1 used the Roth prescription (Mini unitwin, 3M Unitek) with -1 degrees mandibular incisor torque while clinician 2 used the MBT prescription (Victory series, 3M Unitek) with -6 degrees torque for lower incisors. Clinician 1 also used low torque Damon bracket for some patients with torque values of -11 degrees, which was adjusted for in the statistical model. Other considerations for a difference of 3.0 degrees less mandibular incisor proclination with self-ligation brackets may be related to differing archwire sequences leading to different torque expression, and treatment mechanics (more Class II patients were treated with conventional brackets).

Occlusal quality was measured by scoring the digital models using the PAR index. The final PAR scores were not significantly different for both clinicians. However, a significantly greater percent reduction in PAR scores was observed with conventional bracket for Clinician 2. This may be related to the increased treatment time with conventional brackets seen in Clinician 2's sample. Other studies have not shown any difference in percent PAR improvements and final PAR scores between the two bracket types [Harradine, 2001; Fleming et al., 2010; DiBiase et al., 2011].

The biggest marketing strategy for self-ligating brackets has always been faster treatment. Our results for Clinician 1 were in accordance with all prospective studies and systematic reviews done so far, indicating no difference in overall treatment time and total number of visits between the two groups. However, for Clinician 2, a very large difference in treatment time of almost 11 months and 7 fewer visits was observed for self-ligation. There was no difference in appointment frequency for the two different bracket systems. Both were calculated to be approximately 0.7 appointments per month (Table 10). Clinician 2 was interviewed after the data analyses to investigate potential reasons for the large discrepancy in treatment time. No performance bias was perceived, as Clinician 2 did not have a preference for one bracket system over the other. However, it is possible that confounding by indication occurred in Clinician 2's office. Evidently, one referring dentist for Clinician 2 requested self-ligating brackets for the patients he referred. The patients from this dentist were often stationed at a nearby military base, and there could have been some bias to treat these patients as quickly as possible due to the potential for relocation/deployment.

Due to this large inconsistency in the results for treatment duration, the data from the two clinicians were not pooled, as originally intended. This resulted in a reduction of the sample size, and the power to detect differences between the self-ligation and conventional bracket groups. Another unexpected occurrence was the extremely low extraction rate that was encountered. Originally, we thought that there might be some bias to treat non-extraction patients with self-ligating brackets. However, what we found was that the extraction rate was extremely low (about 5%), regardless of bracket type used. Due to the very low numbers of extraction patients, we chose to exclude all 7 pairs of subjects in which one patient underwent extractions. These are all potential limitations of retrospective studies, and point out the caution that must be exercised when conducting observational studies.

Assessment of failure rates for both brackets included the number of emergency visits, including unscheduled emergencies, which were not different for the two bracket types in both clinicians' samples. Also, the number of broken brackets was similar for both groups. Other emergencies, including wire pokes due to wire slides, were recorded and showed 59% more sliding events with self-ligating brackets in Clinician 2's patients. Also, another reason for emergencies, loss of ligation due to broken doors in self-ligating brackets and loss of elastomeric ties in conventional brackets, was included in our study. We did not encounter a large number of these events, but they may be have been under-reported in charting.

This study was not able to determine many significant predictors for choosing one bracket type over the other. The only positive finding included the selection of self-ligating brackets with less proclined mandibular incisors by Clinician 1. This was confirmed with the clinician and, was based on the clinicians' personal preference. No other significant trends were noticed. Hence, no assumptions can be derived for selection of either bracket type for a particular patient.

The biggest limitation of this study was its retrospective nature. Ideally, we would propose a randomized controlled trial to compare the two bracket systems. However, RCT's require considerable funding and time to perform. Also, it is difficult to eliminate potential bias from investigators because blinding them to the type of bracket system being used is challenging. Retrospective studies are also subject to various types of bias. In our study, this included slightly different approaches to treatment, such as the arch wires and arch forms, altered wire sequences, inability to control initial parameters, and different patient populations, including a mobile military population for one of the bracket types. We did attempt to minimize bias where possible during the planning stages of the study. For example, we tried to avoid proficiency bias by sampling from practitioners who stated they had considerable experience with both systems, and used both systems simultaneously in their practices. We also sampled consecutively treated subjects and matched the groups based on age and gender to minimize selection bias. We performed all measurements in a blinded fashion. Finally, unlike many studies where the investigators are opponents or proponents of self-ligation, the practitioners in this study stated no preference for either appliance system, and simply tried to provide the most effective and efficient treatment to their patients.

Conclusion

Our study suggests that the bracket system, per se, may not have a major effect on arch dimensions, lower incisor inclination, occlusal outcome, and treatment efficiency. Rather, the variation in these parameters may depend more on other treatment choices made by the clinician, such as archwires, Class II mechanics, or the use of Suresmile. Clinician 1 preferred conventional brackets for patients with more proclined lower incisors. No trends for bracket selection were noted for Clinician 2, and in fact, the use of self-ligating brackets seemed to be influenced by the referring dentist, rather than any condition that the patient presented with initially. This study highlights the challenges of observational studies, and the care that must be exercised when interpreting their findings.

References

Cattaneo PM, Treccani M, Carlsson K, Thorgeirssson T, Myrda A, Cevidanes L, Melson B. Transversal maxillary dento-alveolar changes in patients treated with active and passive self-ligating brackets: a randomized clinical trial using CBCT-scans and digital models. Orthod Craniofac Res 2011;14:223-233.

Cattaneo PM, Salih RA, Melson B. Labio-lingual root control of lower anterior teeth and canines obtained by active and passive self-ligating brackets. Angle Orthod 2013;83:691–697.

Chen SS, Greenlee GM, Kim JE, Smith CL, Huang GJ. Systematic review of self-ligating brackets. Am J Orthod Dentofacial Orthop 2010;137:726:e1-8.

Damon DH. The rationale, evolution and clinical application of the self-ligating bracket. Clin Orthod Res 1998;1:52-61.

DiBiase AT, Nasr IH, Scott P, Cobourne MT. Duration of treatment and occlusal outcome using Damon3 self-ligated and conventional orthodontic bracket systems in extraction patients: A prospective randomized clinical trial. Am J Orthod Dentofacial Orthop 2011;139:e111-116.

Eberting JJ, Straja SR, Tuncay OC. Treatment time, outcome, and patient satisfaction comparisons of Damon and conventional brackets. Clin Orthod Res 2001;4:228-34.

Ehsani S, Mandich MA, El-Bialy TH, Flores-Mir C. Frictional resistance in self-ligating orthodontic brackets and conventionally ligated brackets. A systematic review. Angle Orthod 2009;79: 592-601.

Fleming PS, DiBiase AT, Sarri G, Lee RT. Efficiency of mandibular arch alignment with 2 preadjusted edgewise appliances. Am J Orthod Dentofacial Orthop. 2009;135: 597–602.

Fleming PS, DiBiase AT, Sarri G, Lee RT. Comparison of mandibular arch changes during alignment and leveling with 2 preadjusted edgewise appliances. Am J Orthod Dentofacial Orthop. 2009;136:340–347.

Fleming PS, DiBiase AT, Lee RT. Randomized clinical trial of orthodontic treatment efficiency with self-ligating and conventional fixed orthodontic appliances. Am J Orthod Dentofacial Orthop 2010;137:738-742.

Fleming PS, Johal A. Self-ligating brackets in orthodontics. A systematic review. Angle Orthod 2010;80:575-584.

Fleming PS, O'Brien K. Self-ligating brackets do not increase treatment efficiency. Am J Orthod Dentofacial Orthop 2013;143:9-10.

Fleming PS, Lee RT, Marinho V, Johal A. Comparison of maxillary arch dimensional changes with passive and active self-ligation and conventional brackets in the permanent dentition: A multicenter, randomized controlled trial. Am J Orthod Dentofacial Orthop 2013;144:185-193.

Franchi L, Baccetti T, Camporesi M, Lupoli M. Maxillary arch changes during leveling and aligning with fixed appliances and low-friction ligatures. Am J Orthod Dentofacial Orthop 2006;130:88–91.

Germane N, Lindauer S J, Rubenstein L K, Revere J H, Isaacson R J 1991 Increase in arch perimeter due to orthodontic expansion. Am J Orthod Dentofacial Orthop 100: 421–427.

Hamilton R, Goonewardene MS, Murray K. Comparison of active self-ligating brackets and conventional pre-adjusted brackets. Aust Orthod J 2008;24:102-9.

Harradine NW. Self-ligating brackets and treatment efficiency. Clin Orthod Res 2001;4:220-7.

Harradine NW. Self-ligating brackets: where are we now? Journal of Clinical Orthodontics 2003;30:262–273.

Harradine NW. The history and development of self-ligating brackets. Seminars in Orthodontics 2008;14:5-18.

Harradine NW. Self-ligating brackets increase treatment efficiency. Am J Orthod Dentofacial Orthop 2013;143:9-10.

Jiang RP, Fu MK. Non-extraction treatment with self-ligating and conventional brackets. Zhonghua Kou Qiang Yi Xue Za Zhi 2008;43:459-463.

Johannson K, Lundstrom F. Orthodontic treatment efficiency with self-ligating and conventional edgewise twin brackets. Angle Orthod 2012;82:929-934.

Keim RG, Gottlieb EL, Nelson AH, Vogels DS III. JCO study of orthodontic diagnosis and treatment procedures. Part 1: results and trends. J Clin Orthod. 2008;42:625–640.

Lenth, R. V. (2006-9). Java Applets for Power and Sample Size [Computer software]. Retrieved *01/25/12,* from http://www.stat.uiowa.edu/~rlenth/Power.

Little, RM. The irregularity index: a quantitative score of mandibular anterior alignment. Am J Orthod Dentofacial Orthop 1975;68:554-563.

Marshall SD, Currier GF, Hatch NE, Huang GJ, Nah H, Owens SE, Shroff B, Southard TE, Suri L, Turpin DL. Self-ligating bracket claims. American Journal of Orthodontics and Dentofacial Orthopedics 2010;138(2),128-131.

Miles PG. SmartClip versus conventional twin brackets for initial alignment: is there a difference? Aust Orthod J. 2005; 21:123–127.

Miles PG, Weyant RJ, Rustveld L. A clinical trial of Damon 2 vs conventional twin brackets during initial alignment. Angle Orthod. 2006;76:480–485.

Ong E, McCallum H, Griffin MP, Hod C. Efficiency of self-ligating vs conventionally ligated brackets during initial alignment. Am J Orthod Dentofacial Orthop 2010;138:138.e1-138e7.

Paduano S, Cioffi I, Iodice G, Rapuano A, Silva R. Time efficiency of self-ligating vs conventional brackets in orthodontics: effect of appliances and ligating systems. Prog Orthod 2008;9: 74-80.

Pandis N, Polychronopoulou A, Eliades T. Failure rate of self- ligating and edgewise brackets bonded with conventional acid etching and a self-etching primer: a prospective in vivo study. Angle Orthod 2006;76:119-122.

Pandis N, Polychronopoulou A, Eliades T. Self-ligating vs conventional brackets in the treatment of mandibular crowding: a prospective clinical trial of treatment duration and dental effects. Am J Orthod Dentofacial Orthop. 2007;132:208–215.

Pandis NP, Polychronopoulou A, Makou M, Eliades T. Mandibular dental arch changes associated with treatment of crowding using self-ligating and conventional brackets. Eur J Orthod 2010;32:248–253.

Pandis NP, Polychronopoulou A, Katsaros C, Eliades T. Comparative assessment of conventional and self-ligating appliances on the effect of mandibular intermolar distance in adolescent nonextraction patients: A single-center randomized controlled trial. Am J Orthod Dentofacial Orthop 2011;140:e99-105.

Prettyman C, Best AM, Lindauer SJ, Tufekci E. Self-ligating vs conventional brackets as perceived by orthodontists. Angle Orthod. 2012;82:1060–1066.

Rinchuse DJ, Miles PG. Self-ligating brackets: present and future. Am J Orthod Dentofacial Orthop 2007;132:216-222.

Scott P, DiBiase AT, Sherriff M, Cobourne MT. Alignment efficiency of Damon 3 self-ligating and conventional orthodontic bracket systems: a randomized clinical trial. Am J Orthod Dentofacial Orthop. 2008;134:470.e1–470.e8.

Stolzenberg J. The Russell attachment and its improved advantages. Int J Orthodont Dent Child. 1935;21:837–840.

Thorstenson GA, Kusy RP. Resistance to sliding of self-ligating brackets versus conventional stainless steel twin brackets with second-order angulation in the dry and wet (saliva) states. Am J Orthod Dentofacial Orthop 2001;120:361-70.

Turnbull NR, Birnie DJ. Treatment efficiency of conventional vs self-ligating brackets: effects of archwire size and material. Am J Orthod Dentofacial Orthop 2007;131:395-9.

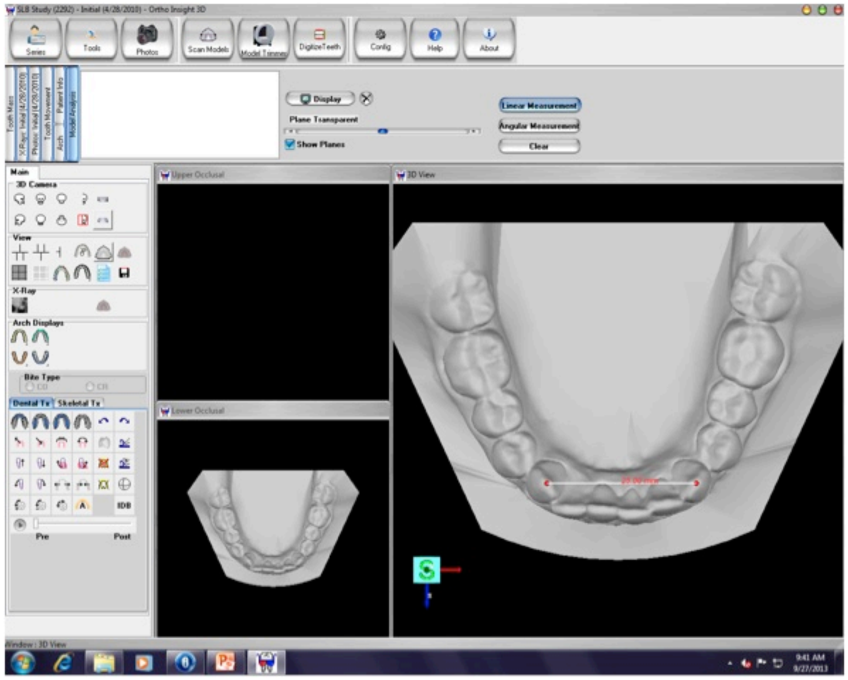

Figure 1. Measurement of mandibular intercanine width

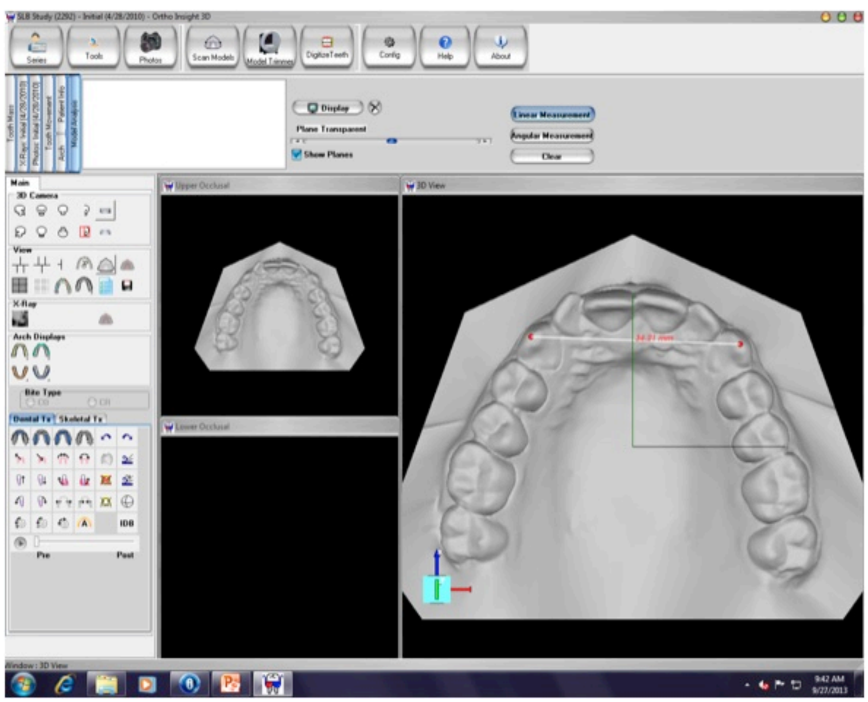

Figure 2. Measurement of maxillary intercanine width

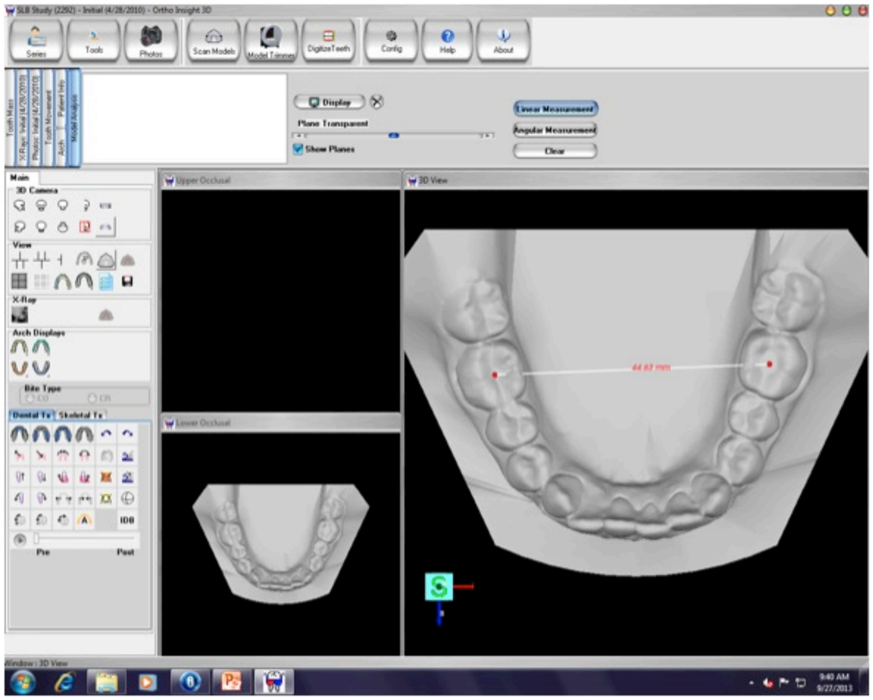

Figure 3. Measurement of mandibular intermolar width

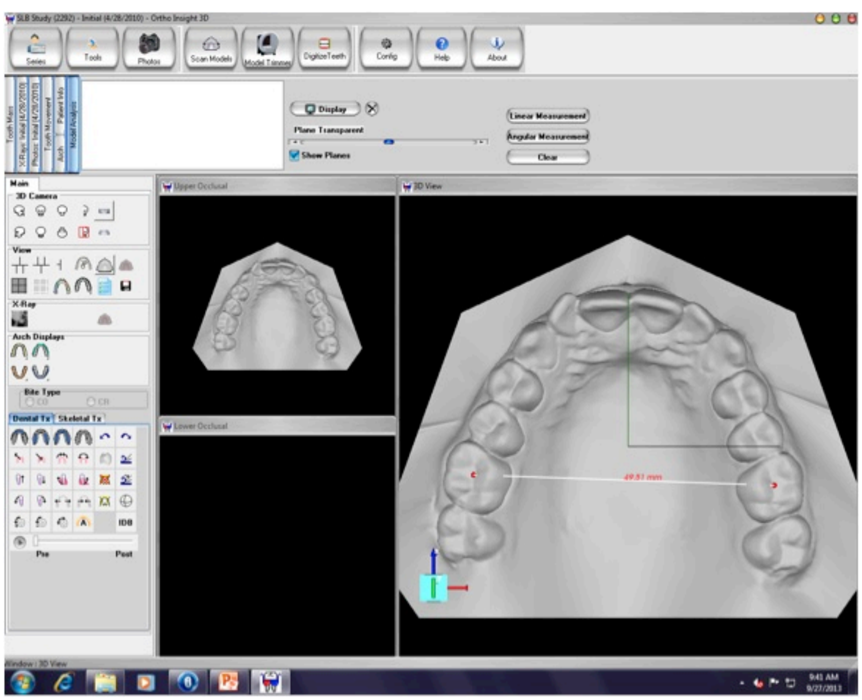

Figure 4. Measurement of maxillary intermolar width

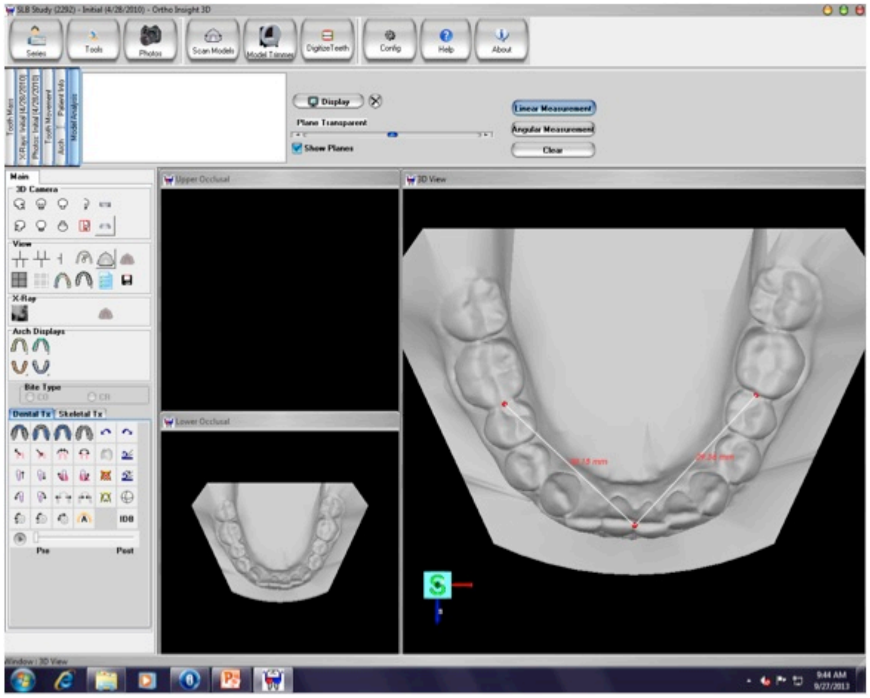

Figure 5. Measurement of mandibular arch length

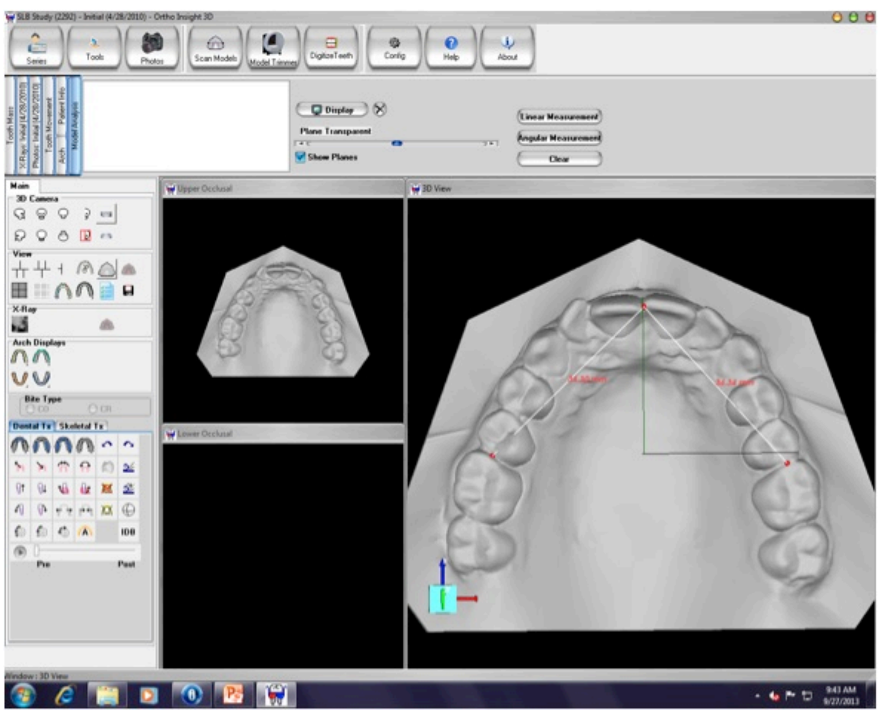

Figure 6. Measurement of maxillary arch length

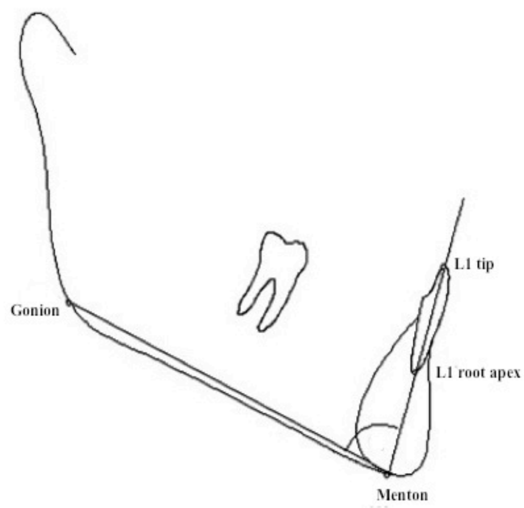

Figure 7. Measurement of lower incisor inclination relative to mandibular plane

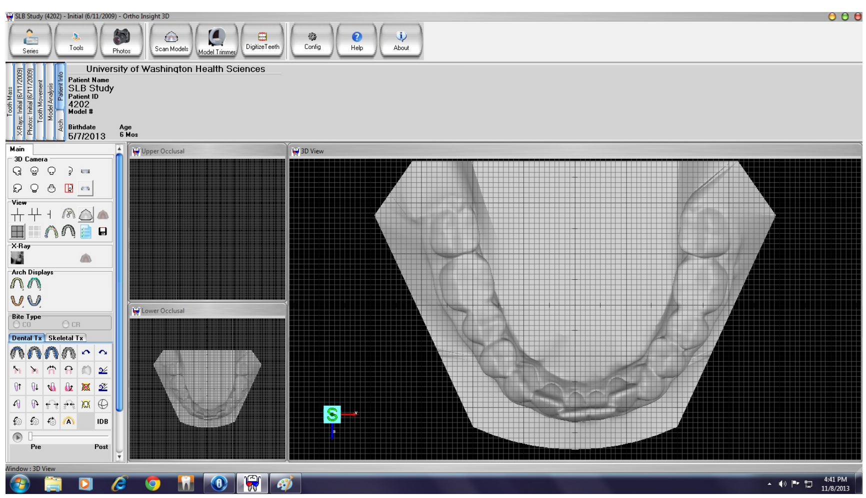

Figure 8. Measurement of contact point displacement for PAR score

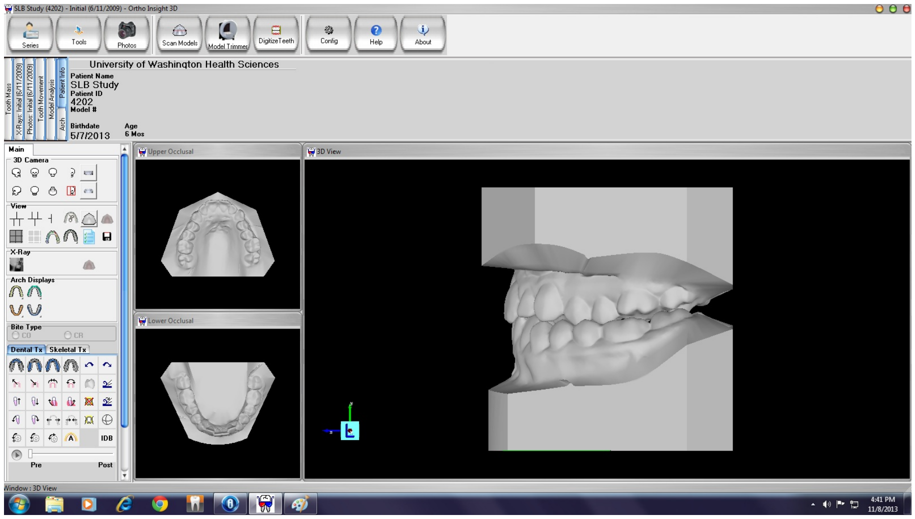

Figure 9a. Buccal occlusion assessment for PAR score

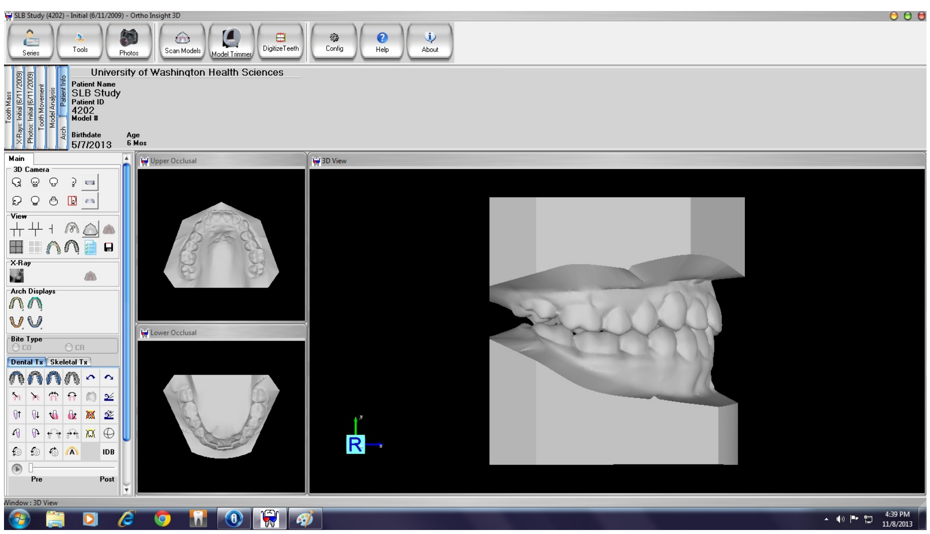

Figure 9b. Buccal occlusion assessment for PAR score

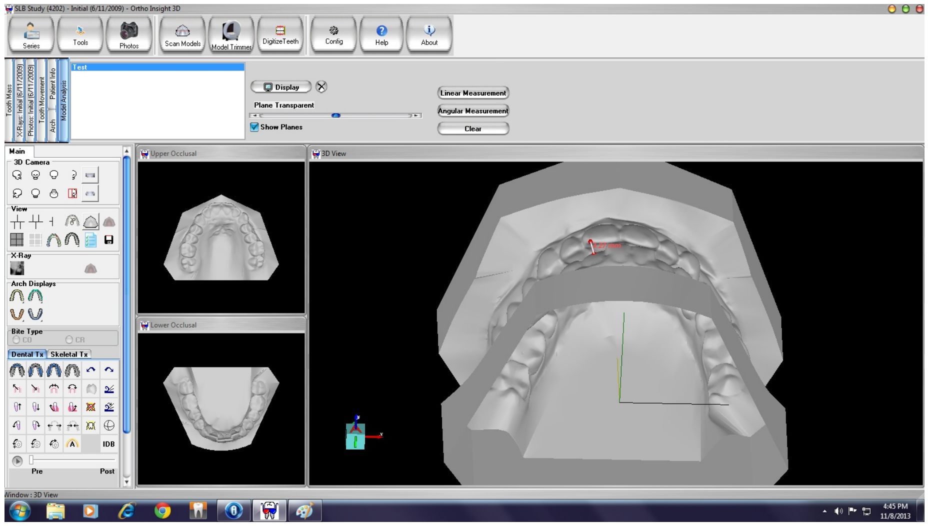

Figure 10a. Measurement of overjet for PAR score

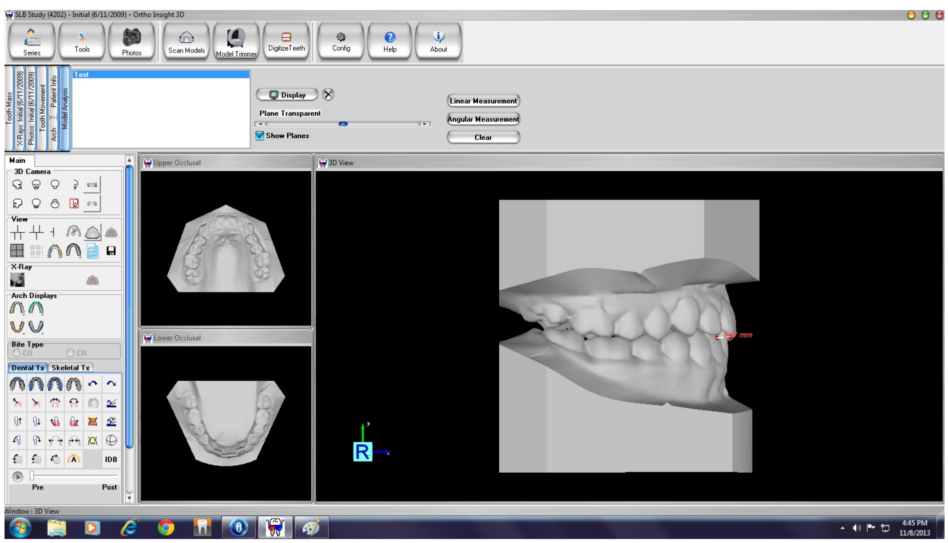

Figure 10b. Measurement of overjet for PAR score

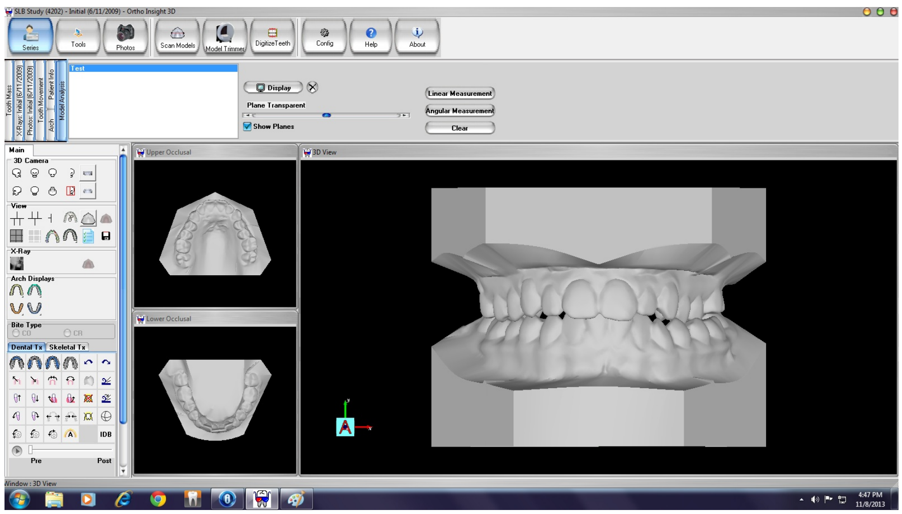

Figure 11. Measurement of overbite and centerline for PAR score

Table 1a. Sample size calculation based on treatment duration

	Significant difference	Estimated SD for treatment duration	Sample size required in each group
Treatment duration	3 months	5.2	47
	4 months		27
	5 months		17
	6 months		12

Table 1b. Sample size calculation based on change in intercanine width

	Significant difference	Estimated SD for change in intercanine width	Sample size required in each group
Change in intercanine width	1 mm	1.6	40
	1.5 mm		18
	2 mm		10
	2.5 mm		7

Table 1c. Sample size calculation based on lower incisor inclination

	Significant difference	Estimated SD for change in lower incisor inclination	Sample size required in each group
Change in lower incisor inclination	3 degrees	3.7	24
	5 degrees		9
	7 degrees		5
	9 degrees		3

Table 2. Pretreatment Demographic characteristics

	Clinician 1		Clinician 2	
	Self-ligating bracket (N=37) Mean (SD) or N (%)	**Conventional bracket** (N=37) Mean (SD) or N (%)	**Self-ligating bracket** (N=17) Mean (SD) or N (%)	**Conventional bracket** (N=17) Mean (SD) or N (%)
Age (years)	13.5 (1.4)	13.5 (1.3)	13.8 (1.6)	13.7 (1.5)
Gender				
Male	15 (40.5)	15 (40.5)	9 (52.9)	9 (52.9)
Female	22 (59.5)	22 (59.5)	8 (47.1)	8 (47.1)

Table 3. Pretreament clinical characteristics

	Clinician 1		Clinician 2	
	Self-ligating bracket (N=37) Mean (SD) or N(%)	**Conventional bracket** (N=37) Mean (SD) or N(%)	**Self-ligating bracket** (N=17) Mean (SD) or N(%)	**Conventional bracket** (N=17) Mean (SD) or N (%)
Malocclusion				
Class I	12 (32.4)	13 (35.1)	9 (52.9)	6 (35.3)
Class II	19 (51.4)	23 (62.2)	8 (47.1)	11 (64.7)
Class III	6 (16.2)	1 (2.7)	0 (0)	0 (0)
Crowding (mm)	5.6 (3.6)	4.5 (3.1)	4.9 (2.9)	4.6 (3.3)
Overjet (mm)	3.1 (2.1)	3.6 (1.5)	3.2 (1.6)	4.3 (2.4)
Mandibular arch dimensions (mm)				
Intercanine width	25.9 (2.2)	25.7 (1.7)	26.5 (2.7)	26.2 (2.3)
Intermolar width	41.9 (3.1)	41.6 (2.2)	41.5 (2.2)	41.8 (3.0)
Arch length	59.6 (4.0)	60.6 (3.3)	62.6 (4.0)	60.3 (4.5)
Maxillary arch dimensions (mm)				
Intercanine width	34.2 (3.1)	34.7 (1.9)	35.1(2.4)	34.4 (1.8)
Intermolar width	46.3 (3.4)	47.3 (2.5)	46.8 (2.0)	46.4 (2.9)
Arch length	69.2 (4.6)	70.6 (3.8)	72.2 (4.5)	69.7 (4.0)
Lower incisor inclination (deg)	**90.8 (6.8)**	**94.4 (6.9)***	95.2 (4.7)	92.7 (5.0)
PAR score	**24.0 (10.9)**	**17.4 (7.7) ***	15.6 (9.7)	20.4 (9.3)

* P value below 0.5

Table 4. Miscellaneous factors

	Clinician 1		**Clinician 2**	
	Self-ligating bracket (N=37) N (%)	**Conventional bracket** (N=37) N (%)	**Self-ligating bracket** (N=17) N (%)	**Conventional bracket** (N=17) N (%)
IPR	3 (8.1)	2 (5.4)	4 (23.5)	4 (23.5)
Suresmile	**9 (24.3)**	**1 (2.7) ***	0 (0)	0 (0)
Phase I treatment	18 (48.6)	21 (56.8)	3 (17.6)	4 (23.5)
Low torque brackets	**6 (16.2)**	**0 (0) ***	0 (0)	0 (0)

* P value below 0.5

Table 5. Arch dimension changes

	Clinician 1			Clinician 2		
Outcome	**Self-ligating bracket** (N=37) Mean (SD)	**Conventional bracket** (N=37) Mean (SD)	**Diff** (95% CI)	**Self-ligating bracket** (N=17) Mean (SD)	**Conventional bracket** (N=17) Mean (SD)	**Diff** (95% CI)
Mandibular arch dimensions (mm)						
Intercanine width	1.1 (1.9)	1.0 (1.5)	0.1 (-0.7 – 0.9)	**1.4 (1.4)**	**0.2 (1.7)**	**1.2 (0.1 – 2.3)***
Intermolar width	0.8 (2.3)	0.6 (1.7)	0.2 (-0.7 – 1.1)	**2.2 (1.4)**	**0.5 (1.6)**	**1.6 (0.6 – 2.7)***
Arch length	**2.3 (3.2)**	**0.5 (2.3)**	**1.8 (0.5 – 3.1)***	-0.2 (2.5)	0.9 (3.8)	-1.1 (-3.4 - 1.1)
Maxillary arch dimensions (mm)						
Intercanine width	0.7 (3.0)	-0.3 (1.9)	1.0 (-0.3 – 2.2)	**1.5 (3.4)**	**-0.8 (1.5)**	**2.3 (0.0 - 4.5)***
Intermolar width	0.6 (2.1)	0.3 (1.9)	0.3 (-0.6 – 1.2)	0.3 (3.2)	0.7 (1.8)	-0.4 (-2.2 - 1.4)
Arch length	**2.0 (3.7)**	**0.0 (2.6)**	**2.0 (0.5 – 3.5)***	-0.5 (3.1)	0.3 (4.0)	-0.8 (-3.4 - 1.7)

* P value below 0.05

Table 6. Lower incisor inclination changes

	Clinician 1			Clinician 2		
Outcome	**Self-ligating bracket** (N=37) Mean (SD)	**Conventional bracket** (N=37) Mean (SD)	**Diff (95% CI)**	**Self-ligating bracket** (N=17) Mean (SD)	**Conventional bracket** (N=17) Mean (SD)	**Diff (95% CI)**
Lower incisor inclination (deg)	5.6 (6.3)	4.9 (5.2)	0.7 (-1.9 – 3.4)	**1.5 (4.3)**	**6.0 (7.4)**	**-4.5 (-8.7- -0.2)***
Adjusted		Reference	0.9 (-2.0 – 3.7) [a]		Reference	-3.0 (-6.8 – 0.8)[b]

* P value below 0.05

[a] adjusted for initial lower incisor inclination, low torque brackets, and Angle classification.

[b] adjusted for initial lower incisor inclination and Angle classification.

Table 7. Peer Assessment Rating (PAR) score changes

	Clinician 1			Clinician 2		
Outcome	**Self-ligating bracket** (N=37) Mean (SD)	**Conventional bracket** (N=37) Mean (SD)	**Diff (95% CI)**	**Self-ligating bracket** (N=17) Mean (SD)	**Conventional bracket** (N=17) Mean (SD)	**Diff (95% CI)**
Final PAR score	4.2 (3.6)	3.7 (2.4)	0.5 (-0.9 – 1.9)	3.6 (3.0)	2.1 (1.6)	1.5 (-0.2 – 3.2)
Percent PAR reduction	74.3 (35.8)	72.2 (26.2)	2.2 (-12.4-16.7)	**70.3 (30.0)**	**89.0 (7.9)**	**-18.7 (-34.1- -3.4)***
Adjusted Final PAR		Reference	0.4 (-1.1 – 1.9)[a]		Reference	1.6 (-0.1 – 3.4)[a]
Adjusted percent PAR reduction		Reference	-9.8(-22.9 – 3.4)[a]		**Reference**	**-15.7(-31.2- -0.2)[a]***

* P value below 0.05

[a] adjusted for initial PAR score

Table 8. Treatment duration

	Clinician 1			Clinician 2		
Outcome	**Self-ligating bracket** (N=37) Mean (SD)	**Conventional bracket** (N=37) Mean (SD)	**Diff (95% CI)**	**Self-ligating bracket** (N=17) Mean (SD)	**Conventional bracket** (N=17) Mean (SD)	**Diff (95% CI)**
Treatment duration (mos)	20.7 (3.9)	21.3 (3.2)	-0.6 (-2.2 –1.1)	**19.9 (3.1)**	**31.2 (9.3)**	**-11.2 (-16.1- -6.4)***
Adjusted		Reference	-0.3(-2.1 – 1.5)[a]		Reference	**-10.8(-15.8- -5.7)[b]***

* P value below 0.05

[a] adjusted for suresmile, and initial PAR score

[b] adjusted for initial PAR score

Table 9. Total number of visits

	Clinician 1			Clinician 2		
Outcome	**Self-ligating bracket** (N=37) Mean (SD)	**Conventional bracket** (N=37) Mean (SD)	**Diff (95% CI)**	**Self-ligating bracket** (N=17) Mean (SD)	**Conventional bracket** (N=17) Mean (SD)	**Diff (95% CI)**
Total number of visits	14.8 (3.0)	15.6 (2.4)	-0.8 (-2.1- 0.5)	**13.8 (2.0)**	**21.2 (6.8)**	**-7.4 (-10.9 - -3.9)***
Adjusted		Reference	-0.5(-1.8 – 0.9)[a]		Reference	**-7.0(-10.6 - -3.4)[b] ***

* P value below 0.05

[a] adjusted for suresmile, and initial PAR score

[b] adjusted for initial PAR score

Table 10. Average appointments per month

Bracket type	Clinician 1	Clinician 2
Self-ligating	0.71	0.69
Conventional	0.73	0.68

Table 11. Failure rate

	Clinician 1			Clinician 2		
Outcome	**Self-ligating bracket** (N=37) Mean (SD) or N(%)	**Conventional bracket** (N=37) Mean (SD) or N(%)	**Diff (95% CI)**	**Self-ligating bracket** (N=17) Mean (SD) or N(%)	**Conventional bracket** (N=17) Mean (SD) or N(%)	**Diff (95% CI)**
Number of emergency visits	2.3 (1.8)	2.0 (2.3)	0.3 (-0.6- 1.3)	3.1 (1.7)	2.2 (2.7)	0.8 (-0.8 – 2.4)
Number of broken brackets	1.2 (1.4)	1.2 (1.7)	0.0 (-0.8- 0.7)	1.9 (1.8)	2.4 (3.6)	-0.5 (-2.5 – 1.5)
Wire sliding event	18 (48.6)	17 (45.9)	2.7	**12 (70.6)**	**2 (11.8)**	**58.8 ***
Loss of ligation	8 (21.6)	3 (8.1)	13.5	1 (5.9)	1 (5.9)	0.0

* P value below 0.05

Table 12. Predictors for bracket selection

	Clinician 1		Clinician 2	
Outcome	**Self-ligating bracket** (N=37) Mean (SD) or N(%)	**Conventional bracket** (N=37) Mean (SD) or N(%)	**Self-ligating bracket** (N=17) Mean (SD) or N(%)	**Conventional bracket** (N=17) Mean (SD) or N(%)
Crowding (mm)	5.6 (3.6)	4.5 (3.1)	4.9 (2.9)	4.6 (3.3)
Overjet (mm)	3.1 (2.1)	3.6 (1.5)	3.2 (1.6)	4.3 (2.4)
Malocclusion				
Class I	12 (32.4)	13 (35.1)	9 (52.9)	6 (35.3)
Class II	19 (51.4)	23 (62.2)	8 (47.1)	11 (64.7)
Class III	6 (16.2)	1 (2.7)	0 (0)	0 (0)
Extractions (from original sample)	1 (2.4)	4 (9.5)	1 (5.3)	1 (5.3)
Lower incisor inclination (deg)	**90.8 (6.8)**	**94.4 (6.9)***	95.2 (4.7)	92.7 (5.0)

Table 13. Intra-examiner reliability

Outcome	Dahlberg's error of method	Coefficient of Reliability
Mandibular arch dimensions (mm)		
Intercanine width	0.31	0.97
Intermolar width	0.25	0.98
Arch length	0.48	0.98
Maxillary arch dimensions (mm)		
Intercanine width	0.39	0.98
Intermolar width	0.25	0.99
Arch length	0.52	0.98
Lower incisor inclination (deg)	1.84	0.90
Crowding (mm)	0.66	0.96