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Self-Ligating vs. Conventional Brackets as Perceived by Orthodontists

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Self-Ligating vs. Conventional Brackets as Perceived by Orthodontists

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Dentistry at Virginia Commonwealth University.

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Abstract

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Introduction: Within the past decade, significant developments, new designs, and numerous proposed advantages of self-ligating (SL) brackets have caused them to gain great popularity among practicing orthodontists. The purpose of this study was to determine if there are significant clinical differences between SL and conventional brackets on orthodontic treatment as perceived by practicing orthodontists, and more specifically, if the proposed advantages of SL brackets are evident in clinical practice.

Methods: A survey was developed to evaluate how SL brackets compare to conventional brackets when perceived by practicing orthodontists (n=430). The initial series of questions focused on individual practitioner characteristics and the clinician's experience with SL brackets, while the second part of the survey allowed the orthodontists to indicate a preference for either SL or conventional brackets in regard to a variety of treatment factors.

Results: Most of the responding orthodontists (90%) had experience using SL brackets in clinical practice. SL brackets were preferred for the majority of orthodontic treatment factors, and were most significantly indicated as having shorter adjustment appointments ($P < 0.0001$), providing faster initial treatment progress ($P < 0.0001$), and were the most preferred bracket during the initial alignment stage of treatment ($P < 0.0001$). On the other hand, practitioners reported a stronger preference for conventional brackets during the finishing and detailing stages of treatment ($P < 0.0001$), and regarded conventional brackets as being significantly more cost effective than SL brackets ($P < 0.0001$). Less emergency appointments were also reported with conventional brackets compared to SL brackets ($P < 0.0001$). Despite the perceived overall preference for SL brackets, more than one-third of practitioners no longer use or are planning on discontinuing use of SL brackets. In many circumstances, the orthodontists' bracket preference was significantly influenced by the proportion of patients they treated with SL brackets ($P < 0.0001$), the number of cases it took them to become accustomed to SL brackets ($P < 0.0001$), and their average appointment intervals for both SL brackets ($P < 0.0001$) and conventional brackets ($P = 0.0002$).

Conclusion: Overall, the orthodontists participating in this study reported a perceived difference between SL brackets and conventional brackets on orthodontic treatment. SL brackets were found to be preferred for the majority of the treatment factors, while there were a few situations in which conventional brackets were preferred. Ultimately, due to the lack of high-quality evidence supporting SL brackets, more objective, evidence-based research is essential in order to evaluate definitively the clinical differences of SL and conventional brackets on orthodontic treatment.

Introduction

Self-ligating (SL) brackets were originally introduced in the early 20th century and, until recently, did not receive much attention in the orthodontic profession. Within the past decade, significant developments, new designs, and numerous proposed advantages of SL brackets have caused them to gain great popularity among practicing orthodontists.[1] Currently, the orthodontic market is flooded with the promotion of different SL brackets. Unlike conventional brackets, SL brackets have a mechanical device that secures the archwire in the bracket slot, thereby eliminating the need for elastic or wire ligatures. This advanced form of ligation can be accomplished either "actively" by a spring clip that presses against the archwire, or "passively" in which the clip or rigid door minimizes contact with the archwire.

Manufacturers and advocates of SL brackets have proposed many advantages of SL over conventional brackets. Possibly the most advantageous feature proposed with this ligation method is a combination of reduced friction between the archwire and the bracket along with more secure full archwire engagement.[1,2] Together, these properties have been suggested to allow more rapid alignment of teeth and faster space closure, while maintaining excellent control of tooth position.[1,2] It is believed that with the mechanics of self-ligation, greater arch expansion with less incisor proclination is achieved and, therefore, fewer extractions are required to provide space for tooth movement.[3] Several other claimed advantages of SL brackets include less chairside assistance needed, faster archwire removal and ligation, shorter treatment time with fewer appointments, increased patient comfort, better oral hygiene, and increased patient cooperation and acceptance.[2,4]

The emerging clinical popularity of SL systems has bypassed the research and evidence to definitely support all the proposed advantages.[2] Numerous conflicting studies comparing SL and conventional brackets have caused controversy regarding the treatment effectiveness of the different bracket systems.[5-12] As a result, the validity of the advantages offered by SL brackets is questioned.

Multiple studies have clearly shown that SL brackets generate significantly lower frictional forces than conventional brackets when archwires are slid parallel to an ideally aligned bracket slot.[5,13-19] However, this is not an accurate depiction of what occurs clinically. When considering different bracket angulations resulting from either malocclusion or tipping of teeth as they slide along the archwire, the difference in friction between the ligation methods is not as apparent. While some studies reported less friction with SL brackets regardless of bracket angulation,[5,18,19] others found that when tipping and angulation are accounted for, SL brackets produce similar or higher friction compared with conventional brackets.[6,20] With regard to archwire size, it is also claimed that the reduced friction of SL brackets is seen only during the early stages of treatment with light wires and, when heavier wires are introduced, friction is comparable between the conventional and SL systems.[21] To summarize these findings about the effects of ligation on frictional resistance, a recent systematic review concluded that in comparison to conventional brackets, SL brackets maintain lower friction when coupled with small round archwires in an ideally aligned arch.[22] Sufficient evidence, however, was not found to claim that SL brackets produce lower friction with large rectangular wires in the presence of tipping and/or torque and in arches with considerable malocclusion.

Theoretically, if frictional resistance is reduced with SL brackets, more efficient treatment due to a decrease in the amount of time to align teeth and close spaces should

be observed with this form of ligation.[23] One of the first studies on treatment efficiency found that patients treated with SL brackets on average finished four months sooner and had four fewer appointments than patients with conventional brackets.[7] Another clinical study found an average reduction in treatment of six months and seven visits for cases treated with a passive SL bracket compared to those with conventional ligation.[24] Contrary to these findings, an abstract published in 2007 found no difference in total treatment time between cases treated with conventional and SL brackets.[8]

In regard to alignment efficiency, a prospective study found no overall difference between the two modes of ligation in the time required to resolve mandibular crowding, although a small difference favoring SL brackets was found in the moderately crowded cases.[25] In similar studies, authors have evaluated several different types of SL brackets on alignment, and none have proven to be more effective at reducing irregularity during the initial stages of treatment than conventional brackets.[26-29] When comparing space closure of first premolar extractions, no difference in the rate of en-masse space closure was found between passive SL brackets and conventional brackets.[30] The results of the previously mentioned studies may reflect the concept that friction is not the most important component of resistance to sliding during clinical treatment. Therefore, even if friction is less with SL brackets, other factors such as binding and notching, that are believed to be similar between ligation methods, may be the major determinants of how well bracketed teeth move along an archwire.[23]

One reported disadvantage of the SL bracket systems is the difficulty in finishing patients with ideal torque control due to the greater play of the archwire in the slot of SL brackets.[31] In one study, SL brackets presented with higher torque loss compared to conventional ceramic and stainless steel brackets.[9] In other studies, SL brackets were

found to be equally efficient in delivering torque to maxillary incisors relative to conventional brackets.[10,32] It was concluded that torque expression was determined primarily by the archwire characteristics, and that the bracket system is of minor importance.[32]

When considering arch dimensional changes, claims have been made that SL brackets produce less incisor proclination and labial protrusion than expected with conventional systems, and that more significant posterior expansion without the need for auxiliary expanders can be accomplished.[33] While this idea leads to a potential shift in treatment that entails fewer extractions and more arch expansion, it subsequently raises questions about the stability of results and the consequences and feasibility of long-term retention provided by this technique.[3] Regardless of these claims, studies that have compared arch changes between SL and conventional brackets reported identical incisor proclination and intercanine expansion with both appliance systems during arch alignment.[34,35] While these studies did show statistically greater intermolar expansion with SL appliances of 0.91 and 1.3 mm, these differences are clinically insignificant since molar expansion of 1 to 2 mm only results in an additional 0.3 to 0.6 mm in arch perimeter.[36]

Initially, SL brackets were introduced to reduce the time of ligation, especially when only steel ligatures were available.[37] Berger and Byloff[38] evaluated the effect of SL brackets in reducing chair time and found that SL brackets saved 10 to 12 minutes per patient compared with steel ligatures and 2 to 3 minutes compared with elastic modules. In light of this study, if a practitioner does 25 archwire changes in a day, he or she could potentially save one hour per day using SL brackets rather than elastomeric ligatures. Other studies have reported lesser reductions in archwire changes of 1.3 minutes, 1

minute, and 25 seconds per arch with SL brackets.[7,14,39] It is ultimately up to each individual practitioner to compare these modest reductions in chair time against the increased expense of SL brackets to determine if this significantly contributes to the efficiency of their practice.[37]

It has also been claimed that SL brackets produce light, continuous forces that are more biologically compatible, which lead to improved patient comfort during tooth movement.[40] This was supported by a prospective study that compared pain levels associated with SL and conventional systems.[11] Patients with SL brackets reported significantly lower mean pain intensity during the initial seven days of fixed appliance treatment. In another study, patients with conventional brackets were found to experience higher, more intense pain for a longer period of time than those with SL brackets.[41] The pain was mostly constant, as opposed to functional chewing/biting pain with SL brackets.[41] In contrast, Scott et al[12] found no differences in perceived discomfort between the two appliances during initial alignment, and other authors reported SL brackets to be more painful than conventional brackets when inserting larger, rectangular archwires.[26,42]

Another proposed advantage of SL brackets is improved oral hygiene in patients undergoing fixed appliance therapy due to decreased plaque retention, since elastomeric ligatures are not needed.[43] In two studies that compared plaque formation and bacteria around the different modes of ligation, less retention of oral bacteria, including streptococci, and fewer bacteria in plaque were found on tooth surfaces bonded with SL brackets compared to conventional brackets.[44,45] Pandis et al,[46] however, failed to show a difference in salivary *Streptococcus mutans* between patients with conventional and SL brackets, and another study revealed no difference in the development of white spot lesions throughout treatment in patients with the two bracket types.[47] Furthermore, a

prospective analysis failed to demonstrate an association between the bracket types and periodontal health following appliance removal.[43] This suggests that while bracket type may influence bacterial load during treatment, this effect may not be sustained after treatment is completed.[48]

The proposed advantages of SL brackets challenge several aspects of conventional orthodontic thought, and many conservative orthodontists are skeptical of this bracket system. Despite this opposition, the recent widespread use of SL brackets indicates that this technique is likely a viable alternative to conventional methods.[4] However, due to the lack of long-standing evidence on the clinical outcomes of SL brackets, this recent bracket trend does demand further scrutiny. In addition to the need for more sound, scientific evidence, an evaluation of actual clinical observation is essential in attempting to resolve the uncertainty of the claimed advantages/disadvantages and treatment outcomes of SL brackets. The purpose of this study was to determine if there are significant clinical differences between SL and conventional brackets on orthodontic treatment as perceived by practicing orthodontists, and more specifically, if the proposed advantages of SL brackets are perceived to be evident in clinical practice.

Materials and Methods

A survey was developed to evaluate how SL brackets compare to conventional brackets as perceived by practicing orthodontists. The survey consisted of a one-page questionnaire that was primarily designed to target claimed advantages of SL brackets to see if the orthodontists agreed with these "claims" based on their experience with these fixed appliances (See Appendix for survey).

The initial series of questions dealt with individual practitioner characteristics and focused on the responding clinician's experience with SL brackets in their practice, such as "How long have you been using SL brackets?" and "What percentage of your patients do you treat with SL brackets?". The second part of the survey assessed a variety of treatment factors, allowing orthodontists to indicate a preference for either SL or conventional brackets based on their experience and perceived clinical results. Duration of treatment time, discomfort experienced by the patients, and likelihood of extraction treatment were only a few of the factors evaluated in this section of the study. Each survey had a blank section for the respondents' comments.

Prior to the study, approval was obtained from the Institutional Review Board of the Virginia Commonwealth University Office of Research. The surveys, with addressed postage paid return envelopes, were mailed to 1000 orthodontists under the age of 60 whose names were randomly selected from the AAO's nationwide database with the AAO's permission. A short explanation of the study was provided on the front page of the survey requesting voluntary participation. There were identifying markers on the surveys to trace back individual respondents, which were matched to a coding list at the mailing center in order to maintain confidentiality of the answers submitted. A follow-up

survey was sent to all the orthodontists who did not return a completed survey with the first mailing.

Survey responses were recorded using an Excel spreadsheet. The results were summarized using SAS software (SAS version 9.2, JMP version 8.0.2, SAS Institute, Inc., Cary NC). In analyzing the individual treatment factors from the second part of the survey to determine if there was a preference for either SL or conventional brackets, a scoring of -1 was used for conventional brackets, 0 for no difference, and +1 for SL brackets. Then, a test of whether the average score was zero indicated whether there was a significant preference one way or the other. The level of statistical significance across all of the items was controlled using a Bonferroni correction, where the nominal level of significance was required to be $P < 0.05/(\text{number of questions})$ or $P < 0.05/13 = 0.0038$.

A multi-way ANOVA was then used to screen each of the practitioner characteristics separately (from the first part of the survey) to determine if they had any association with the overall bracket preference of a practitioner. Statistical significance was kept at $P < 0.05$ for this analysis. Any characteristic found to be significantly related to an overall bracket preference was further analyzed using a repeated-measures mixed-model analysis to determine its significance on the bracket preference for each individual treatment factor. The same Bonferroni correction (with significance at $P < 0.0038$) was used to correct for multiple comparisons.

Results

Of the 1000 addresses on the mailing list, eighteen were not recognized by the post office as deliverable. Therefore, the survey was mailed successfully to 982 orthodontists, of which a total of 430 (44%) were returned. Of the responding practitioners, 385 (90%) reported that they use, or have previously used SL brackets. Table 1 indicates that more than half of the orthodontists (52%) used SL brackets on less than 30% of patients. The majority of the practitioners (73%) had been using SL brackets between two and ten years, and most (76%) became comfortable with SL brackets after treating less than thirty cases.

Overall, there were more orthodontists (65%) who claimed that they do not use SL brackets as a marketing tool for their practice. When comparing appointment intervals of the practitioners, the average interval for conventional brackets was 5.8 weeks (SD = 1.24) versus 7.2 weeks (SD = 1.44) for SL brackets. Therefore, practitioners using SL brackets scheduled an additional 1.4 weeks between appointments, on average, compared to conventional brackets ($P < 0.0001$).

Of the 385 orthodontists who responded that they have used SL brackets, 137 (36%) reported that they no longer use them or are planning on discontinuing. The majority of these orthodontists (59%) stopped using SL brackets because they did not see significant enough advantages to justify expansion of inventory and increased costs associated with these brackets.

Table 1: Practitioner Characteristics

Question	n	%
Approximately what % of your patients do you currently treat with self-ligating brackets?		
0 to 30%	198	52
31 to 70%	58	15
71 to 100%	128	33
How long have/had you been using self-ligating brackets?		
less than 2 yrs	78	20
2 to 10 yrs	280	73
more than 10 yrs	24	6
How many cases did it take for you to become accustomed to self- ligation and feel comfortable using this technique?		
less than 10	147	38
10 to 30	145	38
more than 30	48	13
never became comfortable	43	11
Do/did you use self-ligating brackets as a marketing tool for your practice?		
Yes	134	35
No	247	65
What are/were your average appointment intervals for conventional brackets?		
4 to 5 weeks	103	27
6 to 7 weeks	226	60
8 to 9 weeks	48	13
10 or more weeks	2	1
What are/were your average appointment intervals for self-ligating brackets?		
4 to 5 weeks	24	6
6 to 7 weeks	154	41
8 to 9 weeks	175	46
10 or more weeks	26	7
*If you no longer use self-ligating brackets, or are planning on discontinuing their use, what was the **main** reason for your discontinuation of self-ligation?*		
(a) I was able to achieve better results with conventional brackets than self-ligating brackets.	47	34
(b) I did not see significant enough advantages with self-ligating brackets to justify expansion of inventory/cost.	81	59
(c) I did not like working with self-ligating brackets clinically (bonding issues, ligation technique, etc.).	24	18
(d) Patients did not like self-ligating brackets.	7	5
(e) other	3	2

The practitioners' preferences for either SL or conventional brackets were assessed by responding to statements regarding a variety of treatment factors which are summarized in Table 2. For example, when considering treatment time, 37% of orthodontists indicated that SL brackets yielded a shorter overall treatment time, and 6% reported that conventional brackets yielded a shorter overall treatment time. The remaining 57% of orthodontists reported no difference in overall treatment time between the two bracket types. Using a scoring of -1 for conventional brackets, 0 for no difference, and +1 for SL brackets, a test of whether the average score was zero indicated whether there was a significant preference one way or the other (Figure 1; Table 3). Using a Bonferroni corrected p-value, it was found that there was a significant preference for SL brackets in regard to overall treatment time ($P < 0.0001$). More specifically, 68% of the practitioners who indicated shorter treatment with SL brackets claimed this overall treatment time difference was two to six months less than with conventional brackets.

In evaluating bracket preference, three of the treatment factors had to be reverse scored to demonstrate the actual bracket preference for the situation. These comparisons are marked with asterisks in Table 2, Table 3, and Figure 1. For example, orthodontists were asked to identify which bracket caused more patient discomfort during adjustments. Since the answer actually demonstrated a preference for the opposing bracket type, the score was reversed to demonstrate a preference for the bracket not chosen. This was also done when evaluating the likelihood of extractions and the frequency of emergency visits.

Overall, SL brackets were significantly preferred for nine of the thirteen treatment factors, which can be visualized in Figure 1 and Table 3. In addition to a perception of shorter overall treatment time, orthodontists reported that with SL brackets, patients

present with better oral hygiene (P <0.0001) and experience less discomfort during adjustments (P = 0.0012) than with conventional brackets. Furthermore, it was perceived that assistants prefer working with SL more than conventional brackets (P = 0 .0005), and 64% of orthodontists claimed adjustment appointments are shorter with SL brackets (P <0.0001). In further evaluations, practitioners stated that treatment progresses faster initially using SL brackets (P <0.0001), and for treatment of a crowded dentition, orthodontists reported they were less likely to extract teeth with SL brackets than conventional brackets (P <0.0001). When asked to indicate which bracket was preferred for different stages of treatment, 68% of orthodontists chose SL brackets for initial alignment (P <0.0001) and 54% preferred SL brackets during space closure and anterior-posterior changes (P <0.0001).

While SL brackets were reportedly preferred for the majority of the treatment factors, there were others in which conventional brackets were significantly preferred. Conventional brackets were found by 68% of practitioners to be most cost effective and were significantly preferred over SL brackets in this regard (P <0.0001). Also, less emergency visits were reported with conventional brackets (P <0.0001), and the majority of orthodontists (64%) indicated that they preferred conventional brackets over SL brackets during the finishing and detailing stages of treatment (P <0.0001). With regard to long-term stability and relapse potential, no significant bracket preference was indicated by the practitioners (P = 0.2129).

From all treatment factors combined, the overall bracket preference of an orthodontist was then related to the practitioner characteristics from the initial survey questions seen in Table 1. No significant association was found between an orthodontist's bracket preference and the length of time they used SL brackets (P = 0.1267) or whether

they used SL brackets as a marketing tool (P = 0.1342). There was, however, a significant association between bracket preference and four of the practitioner characteristics. These included the percentage of patients treated with SL brackets (P <0.0001), the number of cases required to become accustomed to SL brackets (P <0.0001), and the average appointment intervals for both conventional brackets (P = 0.0002) and for SL brackets (P <0.0001).

These four characteristics were further analyzed to determine their influence on bracket preference when considering each individual treatment factor. The associations with these four characteristics and each factor are indicated in the right-hand column of Table 2 and explained below the table. For example, when evaluating overall treatment time, the practitioners who preferred SL brackets were those who treated a higher proportion of patients with SL brackets (association A), who quickly became accustomed to SL brackets (association B), and who reported longer appointment intervals for SL brackets (association D). The only treatment factors in which bracket preference was not influenced by any practitioner characteristics were the likelihood of extraction treatment and the frequency of emergency visits.

Table 2: Responses by orthodontists on bracket preference for a variety of treatment factors

	n (%)			
Treatment Factor	**Conventional brackets**	**No difference**	**SL brackets**	**Association**
For a given case, the overall treatment time is shorter with	22 (6%)	214 (57%)	141 (37%)	(A)(B)(D)
During adjustments, patients experience more discomfort with*	102 (27%)	216 (57%)	61 (16%)	(A)(C)(D)
Patients present with better oral hygiene when treated with	17 (4%)	204 (54%)	159 (42%)	(A)(D)
Assistants prefer working with	123 (33%)	70 (19%)	184 (49%)	(A)(D)
Adjustment appointments are shorter with	27 (7%)	110 (29%)	242 (64%)	(A)(D)
For a crowded dentition, I would be more likely to extract teeth using*	113 (30%)	232 (61%)	36 (9%)	
Initially, treatment progresses faster with	10 (3%)	121 (32%)	250 (66%)	(A)(D)
There are more emergency visits with*	26 (7%)	283 (75%)	70 (18%)	
Long-term stability with less relapse potential is better achieved with	16 (4%)	341 (93%)	10 (3%)	(A)
Which bracket system is most cost effective	254 (68%)	48 (13%)	70 (19%)	(A)(C)
Indicate which technique you prefer for each of the following stages of treatment:				
Initial alignment	69 (18%)	54 (14%)	259 (68%)	(A)(B)(D)
Space closure/anterior-posterior changes	106 (28%)	68 (18%)	206 (54%)	(A)(B)(D)
Finishing/detailing	242 (64%)	57 (15%)	81 (21%)	(A)(B)(C)(D)

Association: Between practitioner characteristics and bracket preferences

(A) Practitioners who treated a *higher* proportion of patients with SL brackets reported a significantly stronger preference for SL brackets.

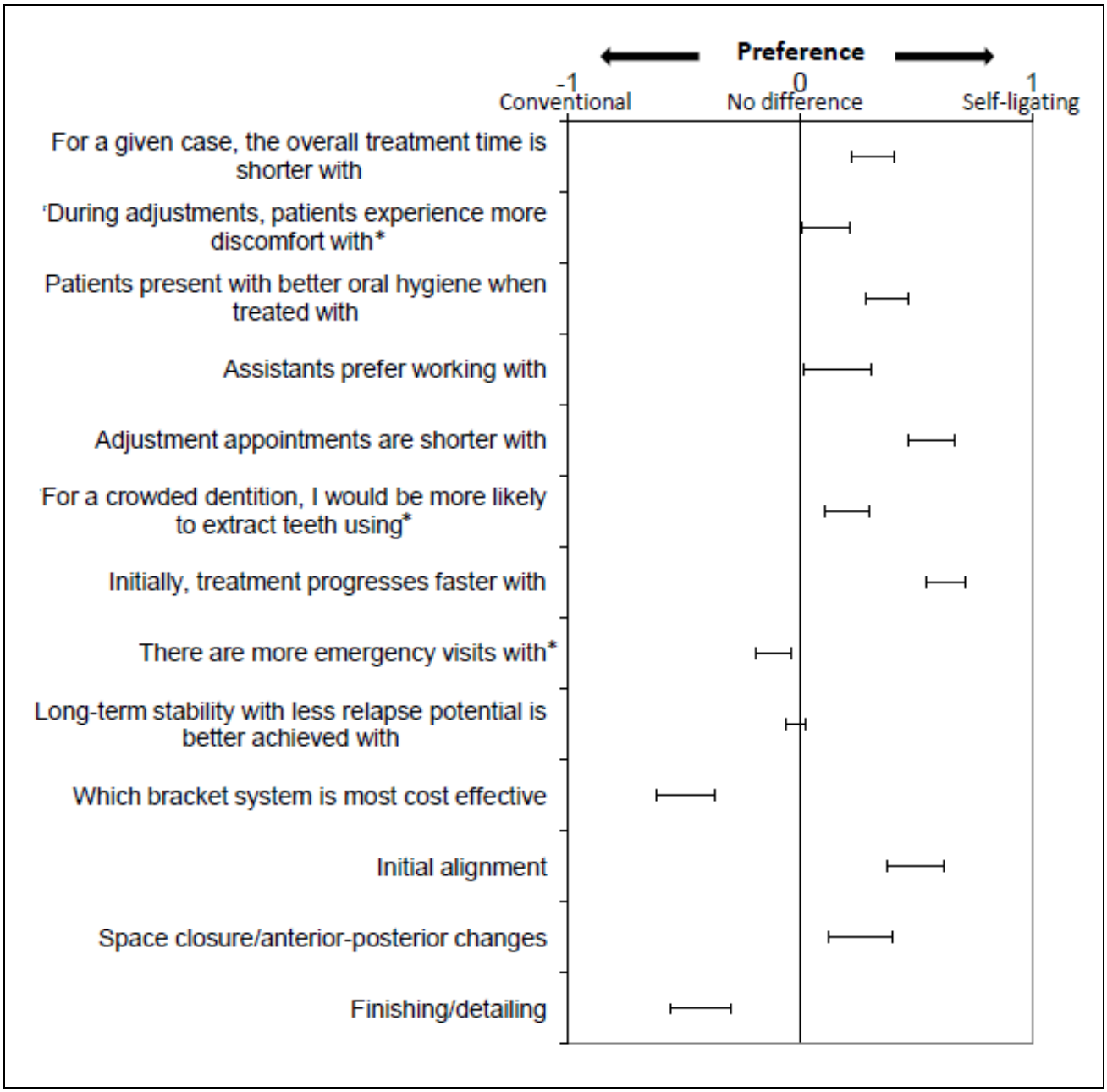
(B) Practitioners who *quickly* became accustomed to SL brackets reported a significantly stronger preference for SL brackets.

(C) Practitioners who reported *longer* appointment intervals for conventional brackets reported a significantly stronger preference for conventional brackets.

(D) Practitioners who reported *longer* appointment intervals for SL brackets reported a significantly stronger preference for SL brackets.

* These items were reverse scored to identify the actual bracket preference

Figure 1: Preferences for SL or conventional brackets for a variety of treatment factors



The bracket preferences are shown as 95% confidence intervals.

* These items were reverse scored to identify the actual bracket preference.

Table 3: Mean bracket preference score for a variety of treatment factors

Treatment Factor	Mean Preference Score (P value)
For a given case, the overall treatment time is shorter with	**.32** (<0.0001)
During adjustments, patients experience more discomfort with*	**0.11** (0.0012)
Patients present with better oral hygiene when treated with	**0.37** (<0.0001)
Assistants prefer working with	**0.16** (0.0005)
Adjustment appointments are shorter with	**0.56** (<0.0001)
For a crowded dentition, I would be more likely to extract teeth using*	**0.20** (0<.0001)
Initially, treatment progresses faster with	**0.63** (<0.0001)
There are more emergency visits with*	**-0.12** (0<.0001)
Long-term stability with less relapse potential is better achieved with	**-0.02** (0.2129)
Which bracket system is most cost effective	**-0.50** (<0.0001)
Initial alignment	**0.50** (<0.0001)
Space closure/anterior-posterior changes	**0.26** (<0.0001)
Finishing/detailing	**-0.43** (<0.0001)

A preference scoring of -1 was used for conventional brackets, 0 for no difference, and +1 for SL brackets, and a test of whether the average score was zero indicated whether there was a significant preference one way or the other.

Statistical significance, after Bonferroni correction, was set at $p< 0.0038$ to achieve an $\alpha= 0.05$ across all of the treatment factors.

*These items were reverse scored to identify the actual bracket preference.

Discussion

Most of the responding orthodontists (90%) had experience using SL brackets in clinical practice. Overall, these practitioners reported a perceived difference between SL and conventional brackets on orthodontic treatment. SL brackets were found to be preferred by orthodontists for the majority of the treatment factors, while there were a few situations in which conventional brackets were preferred. No difference was found in perceived stability or relapse potential between the two bracket types. Despite the perceived overall preference for SL brackets, more than one-third of practitioners (36%) no longer use or are planning on discontinuing use of SL brackets. In many instances, the orthodontist's bracket preference was significantly influenced by the proportion of patients they treated with SL brackets, the number of cases it took them to become accustomed to SL brackets, and their average appointment intervals for both SL and conventional brackets.

Significant developments and new designs, along with the ever increasing promotion from manufacturers and advocates, have greatly aided in the rising popularity of SL brackets within the orthodontic community. A previously repeated survey of American orthodontists showed an exponential rise in the use of SL brackets from 8.7% in 2002 to 42.4% in 2008.[49,50] A more recent journal article in 2009 reported that 75% of the orthodontists surveyed were currently using SL brackets.[51] In another 2009 survey to all US orthodontic programs, 63% of residents stated they are going to use SL brackets in practice, and an additional 30% claimed they might use SL brackets.[52] Only 4% of all responding orthodontic residents reported they are not going to use SL brackets at all. Of the 430 nationwide orthodontists participating in the current survey, 385 (90%) reported they had used SL brackets. It is possible that this survey attracted an increased response

rate from SL bracket users to whom the topic was of more immediate interest, and therefore possibly more motivated to answer the questions, while those with no SL experience may have been more likely to discard the survey and give no response. As a result, the 90% of respondents with SL experience may be higher than what is truly representative of all practicing orthodontists. Regardless, 137 of these respondents (36%) reported they no longer use or are planning on discontinuing use of SL brackets. Of all the participating orthodontists, this leaves a total of 248 (58%) who currently use SL brackets and plan to continue to do so.

From the survey, it appears that most practitioners use SL brackets on either a low percentage or high percentage of patients. This is demonstrated by the fact that 52% of respondents reported using SL brackets on less than 30% of patients, while 33% reported using SL brackets on the majority (70%-100%) of patients. The findings were similar to a 2009 survey of SL bracket users, in which 33% of these practitioners used SL brackets in all their cases and 11% used them in most cases.[51] In the current survey, only 15% of orthodontists, therefore, reported using SL brackets with a somewhat comparable frequency as conventional brackets. Several of the responding orthodontists commented that they use SL brackets only in select cases such as those with high canines or for esthetics in adults to eliminate discoloring ligatures. Overall, the proportion of patients an orthodontist treated with SL brackets correlated significantly with that practitioner's bracket preference. In this regard, it was no surprise that practitioners who treated a higher proportion of patients with SL brackets were more likely to prefer SL over conventional brackets for almost every treatment factor.

Most of the responding orthodontists (73%) had between two and ten years of experience using SL brackets. Twenty percent of respondents had less than two years of

experience, while 6% had used SL brackets for more than ten years. The difference in length of time using SL brackets showed to have no impact on overall bracket preference for the orthodontists. This was surprising, since a practitioner's experience and length of time using a bracket system would be expected to impact their preference for that appliance.

The majority of practitioners (76%) also reported that it took them less than thirty cases to become accustomed to SL brackets to feel comfortable enough to use the appliances. More specifically, 38% of practitioners stated they were even comfortable with SL brackets in less than ten cases. In contrast, 11% of orthodontists claimed they never became comfortable using SL brackets. A responding orthodontist stated, "Self-ligating is a great tool once you are familiar with the system, you know how to use (open/close) brackets, and you are comfortable troubleshooting." Indeed, a significant association was found between a clinician's overall bracket preference and the number of cases it took the clinician to feel comfortable using SL brackets. Practitioners who quickly became accustomed to self-ligation were more likely to prefer SL brackets during all stages of treatment and were also more likely to report a shorter overall treatment time with SL brackets compared to conventional brackets.

While manufacturers are constantly promoting new designs and claiming numerous advantages of SL brackets to the orthodontic community, many orthodontists have likewise begun using SL brackets as a marketing tool for their own practice. These practitioners are advertising this "new" technology and listing the potential advantages of SL brackets to not only patients, but to referring dentists with the hope of increasing referrals. In this study, 35% of orthodontists reported using SL brackets as a marketing tool for their practice, while the remaining 65% claimed they use SL brackets as a

marketing tool. One practitioner claimed, “Patient acceptance is very high with SL brackets because they are considered ‘high tech’.” Another orthodontist remarked, “I personally like conventional brackets for rotational control, but I use self-ligation because my competitors use them.” With the potential increase in competitive marketing of SL brackets, practitioners may begin to feel pushed into using these brackets to protect the success of their business. In this study, there was no association found between the orthodontists’ use of SL brackets as a marketing tool and their overall bracket preference.

It has been suggested that SL brackets permit longer appointment intervals than conventional brackets due to their ability to ensure full and secure archwire engagement of low modulus wires.[1] Intervals of eight to ten weeks have been deemed appropriate when using SL brackets.[1] When comparing the appointment intervals of the responding orthodontists, the average interval for conventional brackets was 5.8 weeks versus 7.2 weeks for SL brackets. This average extension in appointment intervals of 1.4 weeks for SL brackets was statistically significant ($P < 0.0001$). Seven percent of practitioners even reported using intervals of ten or more weeks for SL brackets. One orthodontist commented, “SL brackets are better for patients that need longer intervals between appointments, such as college students, those that live far away, or those who simply have difficulty getting to appointments.” However, one should keep in mind that longer appointment intervals could also result in longer treatment time. In fact, one practitioner who preferred SL brackets and has used them for over five years stated, “I do not use the extended intervals; that did not work for me; treatment time was extended.”

The results of this study indicated a significant relationship between an orthodontist’s appointment intervals and their bracket preference. More specifically, practitioners who reported longer intervals with conventional brackets were more likely

to indicate that patients experience less discomfort during adjustments with conventional rather than SL brackets. These practitioners also indicated that conventional brackets were more cost effective than SL brackets, and they were more likely to prefer conventional brackets during the finishing and detailing stages of treatment. On the other hand, practitioners who reported longer appointment intervals with SL brackets were more likely to prefer SL brackets for the majority of the treatment factors, including faster initial treatment progress, better oral hygiene, shorter adjustment appointments, and an overall shorter treatment time in comparison with conventional brackets. Even with longer appointment intervals for SL brackets, however, these practitioners were not more likely to indicate SL brackets as being more cost effective than conventional brackets.

In this study, 36% of orthodontists discontinued use of SL brackets after their experience with these brackets. Of those orthodontists, 59% reported this decision was primarily the result of not observing significant enough advantages with SL brackets to justify expansion of inventory and increased cost associated with these brackets. One orthodontist stated, "The price difference is ridiculously high and the advantages are non-existent," while another remarked, "The economy has resulted in a drop in starts and exams, and the cost of self-ligating is too high!" In addition, 34% of orthodontists who have discontinued use reported they were able to achieve better results with conventional brackets, and 18% simply did not like working with SL brackets clinically. Several practitioners stated, "Disengagements near finishing actually made me less efficient," "SL brackets don't rotate incisors well at all," and "There is less control, detailing is more difficult, and some cases take longer than two years due to poor finishing." Several orthodontists also claimed they stopped using SL brackets because patients did not like

them, with one stating, “My patients, especially the younger patients, all wanted colored ties.”

While the arguments against SL brackets were made clear by many orthodontists, SL brackets were still found to be statistically significantly preferred by responding practitioners for the majority of the treatment factors presented in the survey. In particular, this preference for SL brackets was found to be most apparent for three factors: shorter adjustment appointments, faster initial treatment progress, and preferred ligation method during the initial alignment stage of treatment.

The original motive for developing SL brackets was to speed the process of ligation.[1] When asked which brackets have shorter adjustment appointments, 64% of orthodontists indicated SL brackets, whereas, only 7% indicated conventional brackets. This revealed a strong statistically significant preference for SL brackets when considering the length of adjustment appointments and a potential reduction in chair time. An orthodontist remarked, “I use SL brackets to make each appointment more efficient. I can adjust and change archwires faster with these brackets.” Previous studies have reported reductions in archwire changes ranging from 25 seconds per arch to 2 to 3 minutes per patient using SL brackets compared to elastomeric ligatures.[7,14,38,39] This increased efficiency is much more apparent when compared to the use of steel ligatures, with time savings of 10 to 12 minutes per patient.[38] On average, most literature indicates that self-ligation results in a modest, yet consistent, reduction in chair time.[53] One study indicated the reduced chair time with SL brackets rather than elastomeric ligatures could save an average of one hour per day.[38] Others pointed out that the modest time savings from the archwire changes represents only a small fraction of the actual chair time during an orthodontic treatment visit.[37] Therefore, it is ultimately up to each individual

practitioner to determine if this is a significant contribution to the efficiency of their practice.

When considering the effect of bracket type on adjustment appointments, one must also evaluate the bracket preference of the assistants, who often are responsible for much of the archwire and bracket handling during these appointments. In this study, only 19% of orthodontists perceived that their assistants did not have a bracket preference. Furthermore, 33% of respondents claimed their assistants preferred conventional brackets and 49% SL brackets. Even though this evaluation is somewhat inadequate, since assistants were not directly surveyed, the results showed a slight preference for SL brackets. Regardless, it is likely for an assistant to simply prefer the bracket type with which they are most familiar. One orthodontist commented, "This question (assistant bracket preference) is tough because my assistants have used conventional brackets for many years," while another simply stated, "My staff hated SL brackets." A different practitioner remarked, "I like SL brackets since they make each assistant equal in their ability to engage the brackets."

In addition to providing shorter adjustment appointments, orthodontists also noted a strong preference for SL brackets when asked which bracket they thought produced faster initial treatment progress, and therefore additionally preferred this ligation method during the initial alignment stage. Sixty-six percent of practitioners perceived initial treatment to progress faster with SL brackets, compared to only 3% who chose conventional brackets. Likewise, 68% of practitioners indicated a preference for SL brackets during the initial alignment stage of treatment, compared to 18% who preferred conventional brackets for this stage. There was also a significant preference for SL

brackets during space closure and anterior-posterior changes. For this stage of treatment, 54% of practitioners preferred SL brackets and 28% preferred conventional brackets.

These reported treatment preferences for SL brackets corresponded with one of the most purported advantages of self-ligation: reduced friction between the archwire and the bracket along with more secure full bracket engagement which, therefore, permits rapid alignment and more certain space closure with excellent control of tooth position.[1,2] These results were conveyed by some orthodontists who stated, "My rotations work out faster with SL brackets," and "I prefer SL in extraction and space closure cases due to better sliding because of less friction." On the other hand, several practitioners stated, "I simply haven't seen the considerable difference that is always discussed that SL brackets are faster in initial alignment than conventional," and "SL brackets have significantly more problems correcting rotations, especially with mandibular incisors, which slows the first stage of treatment." A recent systematic review reported that currently, prospective research considering the efficiency of orthodontic alignment and rate of space closure has consistently shown little difference between SL and conventional brackets.[48] One of these studies found no overall difference between the two modes of ligation in the time required to resolve mandibular crowding.[25] Another study found no difference in the rate of en-masse space closure between passive SL brackets and conventional brackets.[30] These findings are not in agreement with some retrospective studies,[7,24] and with manufacturers' claims of superior clinical performance in moving teeth with SL brackets.[48]

Multiple in vitro studies have clearly shown SL brackets to generate significantly lower frictional forces than conventional brackets when archwires are slid in a passive configuration.[5,13-19] However, when considering the previously mentioned studies

revealing no difference between bracket types for alignment efficiency and space closure, it becomes apparent that other components, besides just friction, must impact these treatment factors as well. In orthodontic tooth movement, if a bracket could be held steady in a passive configuration to the archwire, classic friction, which has been reported to be less with SL brackets, would be the only component of resistance to sliding or movement.[54] However, this condition never occurs clinically since the bracket, along with the tooth, tips relative to the archwire when a force is applied to move it. When this tipping reaches a specific angulation, known as the critical contact angle, the archwire contacts the corners of the bracket and binding occurs, which then contributes to the resistance to sliding.[23] This critical contact angle for brackets has been found to range from approximately 3 to 5 degrees, and as this angulation increases, binding increases and quickly becomes the major source of resistance to sliding while friction becomes insignificant.[23] At an even greater contact angle, notching of the archwire occurs which resists movement until released from contact with the bracket, and both friction and binding become negligible.[23]

Clinical studies have shown that the binding and releasing phenomenon, not frictional resistance, is the major determinant of how well teeth move along an archwire,[23] especially during initial alignment when large contact angles resulting from malposed teeth are encountered. Furthermore, several studies have concluded that binding and notching are independent of ligation method and, therefore, are the same regardless of the bracket type used.[23,54,55] If this is the case, there should be no difference in tooth movement during initial alignment and space closure between the two bracket types.

Other studies, however, have shown passive SL brackets to exhibit a slightly increased critical contact angle due to increased clearance or "slop" between the archwire and bracket slot.[54] With a higher critical contact angle, along with lower initial friction, SL brackets could potentially delay the effects of binding and decrease the inhibition of tooth movement. Nevertheless, this simply would occur by allowing the tooth to tip more and, therefore, would lead to a decrease in control of tooth movement. For this reason, one must weigh the possible initial decrease in resistance to sliding against the loss of control of tooth movement and root position when considering bracket selection.[54]

In further considering alignment efficiency, a couple of practitioners reported, "I have found that it is not so much the bracket type that determines efficiency, but rather the type of archwire used," and "It is the advent of NiTi and copper NiTi wires that speed the case, not SL." Studies seem to agree with these statements, concluding that with regard to the rate of binding and resistance to sliding, size and type of archwire is more important than bracket type.[55,56] During alignment, smaller archwires with a low modulus of elasticity (i.e. 14-mil NiTi) decrease the rate of binding, which leads to less resistance and allows a greater portion of the applied force to be available for "unraveling" the teeth. This occurs independently of the bracket design.[55]

Another commonly proposed advantage of SL brackets, along with less friction, is that these brackets produce a lighter force that is more biologically compatible.[40] Several studies have shown this claim to be erroneous,[57-59] and that in actuality, if frictional resistance is reduced with SL brackets, the resulting unloading force will be greater, not lesser. In a study that simulated the alignment of a lingually malpositioned canine, the average unloading force for the SL group was 128 grams compared to 71 grams with a conventional elastomeric ligature, representing almost a two-fold increase in force.[57] One

must also consider, however, that over a one month period, conventional elastomerics show a force decay of up to 66%, with almost all of this force decay occurring within the first 24 hours.[60] Consequently, the unloading force of a relaxed elastomeric was reported to be 112 grams, which was not statistically different from the forces present in SL systems.[57] Therefore, SL brackets have been shown to produce heavier, or at least equivalent forces compared to conventional brackets, but surely not lighter forces.

The differences in friction due to ligation method have been shown to affect unloading forces mainly when brackets are malposed in a horizontal direction.[58,59] Therefore, any frictional difference between bracket types should only impact alignment forces in the buccolingual dimension. Vertical discrepancies and alignment forces, on the other hand, have been found to be influenced more by binding of the archwire with the corners of the brackets.[58] As mentioned previously, as this vertical displacement increases, along with the contact angle, binding becomes the major determinant of resistance, which is similar between bracket types causing frictional differences to becomes negligible. In one study, however, while finding no difference in alignment force between SL and conventional brackets at 1.5 mm of vertical malalignment, a difference was noted as this displacement increased.[58] At vertical displacements of 4.5 and 6 mm, the amount of released force dropped down to zero for conventional brackets with elastomeric ligatures, whereas the SL brackets still generated forces of about 50 to 100 g. This is consistent with the idea that SL brackets produce greater unloading forces than conventional brackets, however, it also suggests that the difference in friction between the ligation methods, not just the binding effect, may impact the forces available to align teeth in the vertical direction as well.

Along with the improbable claim that SL brackets produce light, biologically compatible forces, proponents additionally state that this may lead to improved patient comfort during tooth movement.[40] In this study, even though significantly more orthodontists perceived SL brackets as producing less patient discomfort during adjustments, this preference was not overwhelming. In fact, 57% of orthodontists indicated there was no difference between bracket types on patient discomfort. One orthodontist even remarked, "Some SL brackets are harder to engage and cause increased discomfort during wire engagement, although technique does play a role in this." This comment was supported by studies that reported SL brackets to be more painful than conventional when inserting larger, rectangular archwires.[26,42] Another practitioner, however, stated, "I have noticed that patients experience less pain with SL." When considering discomfort from tooth movement, one study found no difference in perceived pain between bracket types during initial alignment,[12] whereas another study found that patients with SL brackets reported significantly lower mean pain intensity during the initial seven days of treatment.[11] A recent meta-analysis of the influence of bracket type on subjective pain experience failed to demonstrate a significant advantage for either SL or conventional brackets.[48]

SL brackets have also been proposed to improve oral hygiene in patients due to decreased plaque retention with the elimination of elastomeric ligatures.[43] Forty-two percent of responding orthodontists agreed with this, indicating that patients present with better oral hygiene when treated with SL brackets, while only 4% reported that conventional brackets resulted in better hygiene. Despite this significant preference for SL brackets with regard to oral hygiene, 54% of orthodontists still reported no difference in the oral hygiene of patients between the bracket types. While one orthodontist claimed,

"SL brackets are easier for patients to clean," others remarked, "Hygiene was not better with SL brackets," and "SL brackets are bulkier and retain more food and gunk than conventional brackets." In two studies, less retention of oral bacteria and fewer bacteria in plaque were found on tooth surfaces bonded with SL brackets compared to conventional brackets,[44,45] whereas another study failed to show a difference in salivary *Streptococcus mutans* between patients with the different bracket types.[46] In addition, no difference in the development of white spot lesions were found in patients treated with either SL or conventional brackets.[47] While some of these studies may show that bracket type influences bacterial retention and load during treatment, none have proven that this effect is sustained after treatment is completed.[48]

In conjunction with the previously mentioned claim of more rapid alignment, advocates have proposed that SL brackets reduce treatment time.[37] When asked to indicate which bracket type generally produces shorter overall treatment time, 57% of all orthodontists reported there was no difference between SL and conventional brackets. Thirty-seven percent of practitioners, though, claimed shorter overall treatment time was achieved with SL brackets, which was significant when compared to only 6% who reported shorter treatment with conventional brackets. Despite this significance, one orthodontist stated, "I have treated over 100 cases with SL brackets and have to say I saw no advantage in speed of treatment." A couple of practitioners indicated, "While overall treatment time may be similar between brackets, there are less appointments total when using SL." Studies on treatment efficiency have found that patients treated with SL brackets on average finished four to six months sooner and had four to seven fewer appointment than patients with conventional brackets.[7,24] However, another study found no difference in total treatment time between cases treated with SL or conventional

brackets.[8] Almost 70% of responding orthodontists who indicated SL brackets as having shorter treatment time reported this treatment was two to six months shorter compared to treatment with conventional brackets.

It has been argued that fewer extractions are required with SL brackets due to less incisor proclination and labial protrusion along with more significant posterior expansion.[33] When orthodontists were asked with which bracket type they are more likely to extract teeth, the majority (61%) stated bracket type made no difference for this decision. Nonetheless, significantly more practitioners (30%) claimed they were more likely to extract teeth using conventional brackets compared to only 9% who extracted teeth more with SL brackets. One orthodontist stated, "SL brackets are great for arch expansion, but it is the combination of wires and brackets, not just the brackets, that create the results." Studies comparing arch changes between SL and conventional brackets reported identical incisor proclination and intercanine expansion.[34,35] Although these studies did show slightly greater intermolar expansion with SL brackets, the effect on total arch perimeter was clinically insignificant.[36]

The idea of fewer extractions and more arch expansion subsequently raises questions about the resulting stability and long-term retention provided by SL brackets. When questioned about this, the overwhelming majority of orthodontists (93%) perceived there was no difference in long-term stability and relapse potential between SL and conventional brackets. This was the only treatment factor in the study that showed no significant preference toward either bracket type. In fact, one practitioner remarked, "The question of stability is difficult to answer. Most of what we do is not completely stable long-term." Currently, there is insufficient evidence regarding the influence of bracket

type on long-term stability and future studies are required before any conclusion can be made.

While SL brackets were preferred for the majority of the treatment factors previously discussed, there were situations in which orthodontists significantly preferred conventional brackets. The most significant of these included a stronger preference for conventional brackets during the finishing and detailing stages of treatment, in addition to regarding conventional brackets as being more cost effective than SL brackets.

A reported disadvantage of SL brackets has been the difficulty in finishing patients due to greater clearance or "slop" of the archwire in the slot of SL brackets.[31] The majority of orthodontists (64%) from the survey indicated that they preferred conventional brackets over SL brackets during the finishing and detailing stages of treatment. This preference was found to be significant and was clearly emphasized by many orthodontists who commented, "It is difficult, if not impossible to finish cases with SL. I've stripped and rebonded cases with conventional brackets to finish treatment," "There is not enough third order control with SL brackets, making finishing more difficult," and "Bracket positioning is very critical with SL – the brackets are not forgiving." Other practitioners added, "It is very difficult to place detailed wires with SL brackets," and simply, "Conventional brackets are far superior during finishing." On the contrary, one practitioner claimed, "SL brackets have a better quality of finish because you get to finishing wires faster and have more time to detail." In one study, less ideal torque control was reported with SL brackets compared to conventional brackets.[9] However, other studies have found the bracket types to be equally efficient in delivering torque.[10,32] With regard to the quality of finished cases, SL and conventional brackets were reported to be equivalent at reducing occlusal irregularity as measured by PAR

scores,[7] and cases treated with SL brackets were actually found to have better ABO scores, even when treated in less time than cases with conventional brackets.[24] Overall, it is difficult for studies to compare SL and conventional brackets in their ability to detail and finish cases, and ultimately, it is the responsibility of each individual practitioner to determine with which bracket type they are capable of achieving the best results.

Currently available SL brackets are clearly more expensive than most conventional brackets. A concern repeated by many orthodontists is whether the alleged increase in clinical efficiency with SL brackets justifies the increased cost.[51] From this study, orthodontists significantly preferred conventional brackets in this regard, with the majority of practitioners (68%) indicating that conventional brackets are more cost effective than SL brackets. In fact, the majority of orthodontists who discontinued use of SL brackets reported doing so mainly because they did not see significant enough advantages over conventional brackets to make up for the increased cost. Practitioners stated, "I like SL brackets but the benefits, which are minimal, don't justify the expense," and "I can't believe I was convinced, due to a brilliant marketing campaign, that I should pay 8 times as much for brackets. After years of trying, the advantages just did not show!" However, another practitioner concluded, "Even though there is faster correction of rotations with conventional brackets, the longer appointment intervals and reduced number of visits with SL makes up the difference in bracket costs." As previously mentioned, studies have shown varying amounts of time savings during adjustments with SL brackets, as well as decreased overall treatment times and number of appointments.[7,14,24,38,39] With time often being an expensive commodity, it essentially comes down to each practitioner's time demand when deciding whether or not this will significantly contribute to the efficiency of their practice.

Another consideration when measuring cost efficiency and time savings is the amount of bracket failures and frequency of emergency visits. In a previous survey, the most frequent comment involved the frustration of failed clips with SL brackets that, in turn, necessitated the replacement of these brackets.[51] Some, however, claim that better engineering and manufacturing in recent years has eliminated these concerns. In this study, even though the majority of orthodontists indicated there was no difference in the number of emergency visits between the bracket types, there were still significantly more respondents who believed SL brackets lead to more emergencies than conventional brackets. Several stated, "The doors and clips of SL brackets break too often," "SL brackets kept popping off during archwire changes," and "The archwire would frequently become disengaged between appointments with these brackets." With regard to bracket failure, one study reported SL brackets to be five times more likely to debond compared to conventional brackets.[26] Another study found that the number of debonded brackets and other emergency visits was significantly higher in patients treated with SL compared to conventional brackets.[29]

One weakness of this study in comparing SL to conventional brackets was that SL brackets were referred to and regarded as one uniform group. Permission from the AAO was required to obtain mailing lists to distribute the survey used in this study. Due to antitrust issues, the AAO restricted the use of any brand names in the survey that could have allowed for additional comparisons among varying SL brackets. Therefore, when assessing the results from this study, one must keep in consideration that not all SL brackets are the same, and that differing locking mechanisms (active versus passive) give them unique characteristics that could influence their performance for several of the treatment factors evaluated in this study.

Additionally, this study simply evaluated the perceptions of orthodontists regarding SL and conventional brackets. The subjectivity of the responses and ensuing results were without a doubt susceptible to bias, and the need for more objective research is critical. The most recent systematic review on this topic concluded that there is currently insufficient high-quality evidence to support the use of SL brackets over conventional brackets or vice versa.[48] Therefore, in order to more definitively evaluate the clinical differences between SL and conventional brackets, future high-quality studies with experimental designs directly comparing the two bracket systems are essential to provide the concrete, evidence-based research that is currently lacking in this area.

Conclusion

The orthodontists participating in this study reported a perceived clinical difference between SL and conventional brackets on orthodontic treatment. SL brackets were found to be preferred by orthodontists more often than conventional brackets for the majority of the treatment factors evaluated. In particular, SL brackets were most significantly indicated as facilitating shorter adjustment appointments, providing faster initial treatment progress, and were the most preferred bracket during the initial alignment stage of treatment. On the other hand, there were a few situations in which orthodontists preferred conventional brackets. The most significant of these included a stronger preference for conventional brackets during the finishing and detailing stages of treatment, in addition to regarding conventional brackets as being more cost effective than SL brackets. Orthodontists also reported less emergency appointments with conventional brackets compared to SL brackets. There was no perceived difference in long-term stability and relapse potential between cases treated with either bracket type. Despite the perceived overall preference for SL brackets when assessing treatment factors, more than one-third of the practitioners no longer use or are planning on discontinuing use of SL brackets for various reasons.

In many circumstances, the orthodontist's bracket preference was significantly influenced by the proportion of patients they treated with SL brackets, the number of cases it took them to become accustomed to SL brackets, and their average appointment intervals for both SL and conventional brackets. Overall, more than half of the orthodontists reported using SL brackets on less than 30% of patients, and most became comfortable with SL brackets after treating less than thirty cases. Practitioners' appointment intervals for SL and conventional brackets were significantly different, with

the average interval for conventional brackets being 5.8 weeks versus 7.2 weeks for SL brackets.

While new designs and purported advantages of SL brackets are contributing to their increased popularity among orthodontic practitioners, there is currently insufficient high-quality evidence to truly support their use over conventional brackets or vice versa.[48] More objective, evidence-based research is therefore essential in order to evaluate definitively the clinical differences between SL and conventional brackets on orthodontic treatment.

References

1. Harradine NWT. Self-ligating brackets: where are we now? J Orthod. 2003;30(3):262.

2. Harradine NW. The history and development of self-ligating brackets. Semin Orthod. 2008;14(1):5-18.

3. Birnie D, Harradine NW. Introduction. Semin Orthod. 2008;14(1):1-4.

4. Rinchuse DJ, Miles PG. Self-ligating brackets: present and future. Am J Orthod Dentofacial Orthop. 2007;132(2):216-22.

5. Pizzoni L, Ravnholt G, Melsen B. Frictional forces related to self-ligating brackets. Eur J Orthod. 1998;20(3):283-91.

6. Bednar JR, Gruendeman GW, Sandrik JL. A comparative study of frictional forces between orthodontic brackets and arch wires. Am J Orthod Dentofacial Orthop. 1991;100(6):513-22.

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

8. Yorita R SG. Comparison of self-ligating and conventional orthodontic bracket systems. J Dent Res (Spec Iss A). 2007;86.

9. Morina E, Eliades T, Pandis N, Jger A, Bourauel C. Torque expression of self-ligating brackets compared with conventional metallic, ceramic, and plastic brackets. Eur J Orthod. 2008;30(3):233-38.

10. Pandis N, Strigou S, Eliades T. Maxillary incisor torque with conventional and self-ligating brackets: a prospective clinical trial. Orthod Craniofac Res. 2006;9(4):193-8.

11. Pringle A, Petrie A, Cunningham S, McKnight M. Prospective randomized clinical trial to compare pain levels associated with 2 orthodontic fixed bracket systems. Am J Orthod Dentofacial Orthop. 2009;136(2):160-7.

12. Scott P, Sherriff M, Dibiase A, Cobourne M. Perception of discomfort during initial orthodontic tooth alignment using a self-ligating or conventional bracket system: a randomized clinical trial. Eur J Orthod. 2008;30(3):227-32.

13. Franchi L, Baccetti T, Camporesi M, Barbato E. Forces released during sliding mechanics with passive self-ligating brackets or nonconventional elastomeric ligatures. Am J Orthod Dentofacial Orthop. 2008;133(1):87-90.

14. Shivapuja PK, Berger J. A comparative study of conventional ligation and self-ligation bracket systems. Am J Orthod Dentofacial Orthop. 1994;106(5):472-80.

15. Gandini P, Orsi L, Bertoncini C, Massironi S, Franchi L. In vitro frictional forces generated by three different ligation methods. Angle Orthod. 2008;78(5):917-21.

16. Cacciafesta V, Sfondrini MF, Ricciardi A, Scribante A, Klersy C, Auricchio F. Evaluation of friction of stainless steel and esthetic self-ligating brackets in various bracket-archwire combinations. Am J Orthod Dentofacial Orthop. 2003;124(4):395-402.

17. Krishnan M, Kalathil S, Abraham K. Comparative evaluation of frictional forces in active and passive self-ligating brackets with various archwire alloys. Am J Orthod Dentofacial Orthop. 2009;136(5):675-82.

18. Cordasco G, Farronato G, Festa F, Nucera R, Parazzoli E, Grossi G. In vitro evaluation of the frictional forces between brackets and archwire with three passive self-ligating brackets. Eur J Orthod. 2009;31(6):643-6.

19. Kim T, Kim K, Baek S. Comparison of frictional forces during the initial leveling stage in various combinations of self-ligating brackets and archwires with a custom-designed typodont system. Am J Orthod Dentofacial Orthop. 2008;133(2):187.e15-e24.

20. Redlich M, Mayer Y, Harari D, Lewinstein I. In vitro study of frictional forces during sliding mechanics of "reduced-friction" brackets. Am J Orthod Dentofacial Orthop. 2003;124(1):69-73.

21. Henao SP, Kusy RP. Evaluation of the frictional resistance of conventional and self-ligating bracket designs using standardized archwires and dental typodonts. Angle Orthod. 2004;74(2):202-11.

22. Ehsani S, Mandich M, El-Bialy T, Flores-Mir C. Frictional resistance in self-ligating orthodontic brackets and conventionally ligated brackets. A systematic review. Angle Orthod. 2009;79(3):592-601.

23. Burrow SJ. Friction and resistance to sliding in orthodontics: a critical review. Am J Orthod Dentofacial Orthop. 2009;135(4):442-7.

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

25. 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(2):208-15.

26. Miles PG, Weyant RJ, Rustveld L. A clinical trial of Damon 2 vs conventional twin brackets during initial alignment. Angle Orthod. 2006;76(3):480-5.

27. Scott P, DiBiase A, Sherriff M, Cobourne M. Alignment efficiency of Damon3 self-ligating and conventional orthodontic bracket systems: a randomized clinical trial. Am J Orthod Dentofacial Orthop. 2008;134(4):470.e1-e8.

28. Miles P. SmartClip versus conventional twin brackets for initial alignment: is there a difference? Aust Orthod J. 2005;21(2):123-7.

29. Hamilton R, Goonewardene M, Murray K. Comparison of active self-ligating brackets and conventional pre-adjusted brackets. Aust Orthod J. 2008;24(2):102-9.

30. Miles P. Self-ligating vs conventional twin brackets during en-masse space closure with sliding mechanics. Am J Orthod Dentofacial Orthop.2007;132(2):223-5.

31. Harradine NW, Birnie DJ. The clinical use of Activa self-ligating brackets. Am J Orthod Dentofacial Orthop.1996;109(3):319-28.

32. Huang Y, Keilig L, Rahimi A, Reimann S, Eliades T, Jger A, et al. Numeric modeling of torque capabilities of self-ligating and conventional brackets. Am J Orthod Dentofacial Orthop. 2009;136(5):638-43.

33. Birnie DJ. The Damon Passive Self-Ligating Appliance System. Semin Orthod. 2008;14(1):19-35.

34. Fleming P, DiBiase A, Sarri G, Lee R. Comparison of mandibular arch changes during alignment and leveling with 2 preadjusted edgewise appliances. Am J Orthod Dentofacial Orthop. 2009;136(3):340-7.

35. Pandis N, Polychronopoulou A, Makou M, Eliades T. Mandibular dental arch changes associated with treatment of crowding using self-ligating and conventional brackets. Eur J Orthod. 2009;Epub:1-6.

36. Germane N, Lindauer SJ, Rubenstein LK, Revere JH, Isaacson RJ. Increase in arch perimeter due to orthodontic expansion. Am J Orthod Dentofacial Orthop. 1991;100(5):421-7.

37. Miles PG. Self-ligating brackets in orthodontics: Do they deliver what they claim? Aust Dent J. 2009;54(1):9-11.

38. Berger J, Byloff FK. The clinical efficiency of self-ligated brackets. J Clin Orthod. 2001;35(5):304-8.

39. Turnbull N, Birnie D. Treatment efficiency of conventional vs self-ligating brackets: effects of archwire size and material. Am J Orthod Dentofacial Orthop. 2007;131(3):395-9.

40. Damon DH. The Damon low-friction bracket: a biologically compatible straight-wire system. J Clin Orthod. 1998;32(11):670-80.

41. Tecco S, D'Attilio M, Tet S, Festa F. Prevalence and type of pain during conventional and self-ligating orthodontic treatment. Eur J Orthod. 2009;31(4):380-4.

42. Fleming PS, Dibiase AT, Sarri G, Lee RT. Pain experience during initial alignment with a self-ligating and a conventional fixed orthodontic appliance system. A randomized controlled clinical trial. Angle Orthod. 2009;79(1):46-50.

43. Pandis N, Vlachopoulos K, Polychronopoulou A, Madianos P, Eliades T. Periodontal condition of the mandibular anterior dentition in patients with conventional and self-ligating brackets. Orthod Craniofac Res. 2008;11(4):211-5.

44. Pellegrini P, Sauerwein R, Finlayson T, McLeod J, Covell D, Maier T. Plaque retention by self-ligating vs elastomeric orthodontic brackets: quantitative comparison of oral bacteria and detection with adenosine triphosphate-driven bioluminescence. Am J Orthod Dentofacial Orthop. 2009;135(4):426.e1-e9.

45. van Gastel J, Quirynen M, Teughels W, Coucke W, Carels C. Influence of bracket design on microbial and periodontal parameters in vivo. J Clin Periodontol. 2007;34(5):423-31.

46. Pandis N, Papaioannou W, Kontou E, Nakou M, Makou M, Eliades T. Salivary Streptococcus mutans levels in patients with conventional and self-ligating brackets. Eur J Orthod. 2010 Feb;32(1):94-9.

47. Polat O, Gokcelik A, Arman A, Arhun N. A comparison of White Spot Lesion Formation Between a Self-Ligating Bracket and a Conventional Preadjusted Straight Wire Bracket. World J Orthod. 2008;9(2):e46-e50.

48. Fleming P, Johal A. Self-ligating brackets in orthodontics. Angle Orthod. 2010;80(3):575-84.

49. Keim R, Gottlieb E, Nelson A, Vogels D. 2002 JCO study of orthodontic diagnosis and treatment procedures. Part 1. Results and trends. J Clin Orthod. 2002;36(10):553-68.

50. Keim R, Gottlieb E, Nelson A, Vogels D. 2008 JCO study of orthodontic diagnosis and treatment procedures, part 1: results and trends. J Clin Orthod. 2008;42(11):625-40.

51. Sheridan J. The readers' corner. J Clin Orthod. 2009;43(9):577-9.

52. Noble J, Hechter F, Karaiskos N, Lekic N, Wiltshire W. Future practice plans of orthodontic residents in the United States. Am J Orthod Dentofacial Orthop. 2009;135(3):357-60.

53. Fleming P, DiBiase A, Lee R. Self-ligating appliances: evolution or revolution? J Clin Orthod. 2008;42(11):641-51.

54. Thorstenson G, Kusy R. Comparison of resistance to sliding between different self-ligating brackets with second-order angulation in the dry and saliva states. Am J Orthod Dentofacial Orthop. 2002;121(5):472-82.

55. Thorstenson GA, Kusy RP. Effect of archwire size and material on the resistance to sliding of self-ligating brackets with second-order angulation in the dry state. Am J Orthod Dentofacial Orthop. 2002 Sep;122(3):295-305.

56. Articolo LC, Kusy RP. Influence of angulation on the resistance to sliding in fixed appliances. Am J Orthod Dentofacial Orthop. 1999;115(1):39-51.

57. Petersen A, Rosenstein S, Kim K, Israel H. Force decay of elastomeric ligatures: influence on unloading force compared to self-ligation. Angle Orthod. 2009;79(5):934-8.

58. Baccetti T, Franchi L, Camporesi M, Defraia E, Barbato E. Forces produced by different nonconventional bracket or ligature systems during alignment of apically displaced teeth. Angle Orthod. 2009;79(3):533-9.

59. Pandis N, Eliades T, Bourauel C. Comparative assessment of forces generated during simulated alignment with self-ligating and conventional brackets. Eur J Orthod. 2009;31(6):590-5.

60. Taloumis LJ, Smith TM, Hondrum SO, Lorton L. Force decay and deformation of orthodontic elastomeric ligatures. Am J Orthod Dentofacial Orthop. 1997;111(1):1-11.

Appendix

Survey to Orthodontists

Please circle one response for each question.

1) Have you **ever** used self-ligating brackets?
   (a) Yes **(please complete the remaining questions)**
   (b) No **(please leave the remaining questions blank and return the survey)**

2) Approximately what % of your patients do you currently treat with self-ligating brackets?
   (a) 0 - 30% (b) 31 - 70% (c) 71 - 100%

3) How long have/had you been using self-ligating brackets?
   (a) less than 2 yrs (b) 2 - 10yrs (c) more than 10 yrs

4) How many cases did it take for you to become accustomed to self-ligation and feel comfortable using this technique?
   (a) less than 10 (b) 10 - 30 (c) more than 30 (d) never became comfortable

5) Do/did you use self-ligating brackets as a marketing tool for your practice?
   (a) Yes (b) No

6) What are/were your average appointment intervals for:
   (a) Conventional brackets (in weeks): 4 6 8 10 >10
   (b) Self-ligating brackets (in weeks): 4 6 8 10 >10

7) If you no longer use self-ligating brackets, or are planning on discontinuing their use, what was the **main** reason for your discontinuation of self-ligation? **(leave blank if this does not apply to you)**
   (a) I was able to achieve better results with conventional brackets than self-ligating brackets.
   (b) I did not see significant enough advantages with self-ligating brackets to justify expansion of inventory/cost.
   (c) I did not like working with self-ligating brackets clinically (bonding issues, ligation technique, etc.).
   (d) Patients did not like self-ligating brackets.
   (e) Other:_____

(For each question, please circle one)

8) For a given case, the overall treatment time is shorter with…	Conventional brackets	Self-ligating brackets	No difference
If difference noted, by approximately how much is treatment time shortened: (a) less than 2 months (b) 2 - 6 months (c) more than 6 months			
9) During adjustments, patients experience more discomfort with…	Conventional brackets	Self-ligating brackets	No difference
10) Patients present with better oral hygiene when treated with…	Conventional brackets	Self-ligating brackets	No difference
11) Assistants prefer working with…	Conventional brackets	Self-ligating brackets	No difference
12) Adjustment appointments are shorter with…	Conventional brackets	Self-ligating brackets	No difference
13) For a crowded dentition, I would be more likely to extract teeth using…	Conventional brackets	Self-ligating brackets	No difference
14) Initially, treatment progresses faster with...	Conventional brackets	Self-ligating brackets	No difference
15) There are more emergency visits with…	Conventional brackets	Self-ligating brackets	No difference
16) Long-term stability with less relapse potential is better achieved with…	Conventional brackets	Self-ligating brackets	No difference

17) Which bracket system is most cost effective?	Conventional brackets	Self-ligating brackets	No difference

18) Indicate which technique you prefer for each of the following stages of treatment:

(a) Initial alignment……..	Conventional	Self-ligation	No difference
(b) Space closure/anterior-posterior changes……	Conventional	Self-ligation	No difference
(c) Finishing/detailing……...	Conventional	Self-ligation	No difference

Additional Comments:

Vita

Dr. Chase Prettyman was born in Charleston, West Virginia on August 21, 1982. He was raised in West Virginia and attended West Virginia University for undergraduate studies in Biology. He then attended West Virginia University School of Dentistry where he earned a Doctor of Dental Surgery degree in 2008. He was granted admission to the Department of Orthodontics at Virginia Commonwealth University where he received a Certificate in Orthodontics as well as a Master of Science in Dentistry in 2010. Dr. Chase Prettyman will enter the private practice of orthodontics in Bridgeport, West Virginia.