sciendo

DOI: 10.2478/aoj-2011-0018

Bond failure rates of two self-ligating brackets: a randomised clinical trial

J. Luke Chapman
Private Practice, Ville Platte, LA, United States of America

Aims: To evaluate the bond failure rates of two self-ligating appliance systems bonded with a self-etching primer.
Methods: Forty patients were randomly assigned to either Group SC (SmartClip, 3M Unitek, Monrovia, CA, USA) or Group IR (In-Ovation R, GAC International, Bohemia, NY, USA) appliance groups. Seven hundred and sixty six brackets were bonded with Transbond Plus Self-Etching Primer and Transbond Plus Color Change Adhesive according to the manufacturer's instructions. Over a 12- month period, the survival rates of the brackets were estimated with the Kaplan-Meier analysis. The survival distributions for the appliance systems, dental arch and position in the dental arch were compared with the log-rank test.
Results: The bond failure rate for SC was significantly lower than IR ($p = 0.022$). There were no differences in failure rates between either the maxillary and mandibular arches or between the anterior and posterior brackets.
Conclusion: SC provided a more reliable bond than IR over the 12-month observation period, however, both brackets had clinically acceptable bond failure rates.
(Aust Orthod J 2011; 139-144)

Received for publication: August 2010
Accepted: November 2010

Luke Chapman : lukechapmandds@yahoo.com

Introduction

Although self-ligating brackets were introduced to the profession in the 20th century, they are only now becoming popular with orthodontists.[1] The advantages of self-ligating brackets over conventional twin brackets include reduced retention of plaque and oral bacteria around the brackets and quicker archwire removal and replacement for more efficient office visits.[2,3]

As more manufacturers offer self-ligating brackets, it becomes imperative for clinicians using these appliances to choose the most effective and efficient product. One factor influencing a clinician's choice of appliance is the bond failure rate of the bracket because it directly affects the clinical efficiency of the appliance. For treatment to be successful and completed within a desired time frame, brackets should remain attached to the teeth throughout treatment. Replacing a loose attachment is time-consuming, costly and can prolong treatment.[4,5] Some of the factors considered to influence bond failure rates are the surface area of the bracket base,[6,7] the retentive mechanism of the base[8-12] and the overall design and size of the attachment, including the bucco-lingual profile.

The purpose of this randomised clinical trial was to compare the bond failure rates of two popular self-ligating brackets, In-Ovation R (GAC International, Bohemia, NY, USA) and SmartClip (3M Unitek, Monrovia, CA, USA) over a 12-month period.

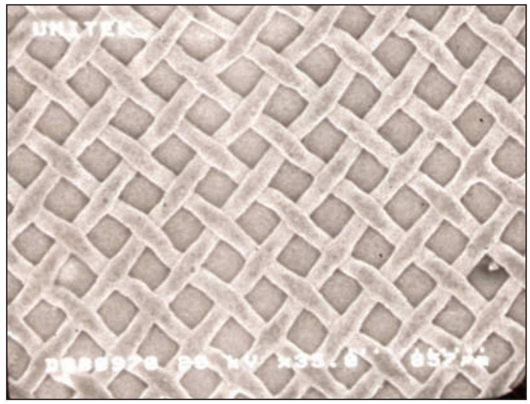
Material and methods

A 'Power' analysis revealed that a sample size of 500 brackets (N = 250 per group) would detect significant differences in bond failure rates after 12 months using a log-rank test, with 90 per cent power and a 5 per cent level of significance. It was decided to recruit 40 patients to compensate for losses due to extractions, congenitally missing teeth and patients who moved during the period of the investigation or who were otherwise excluded.

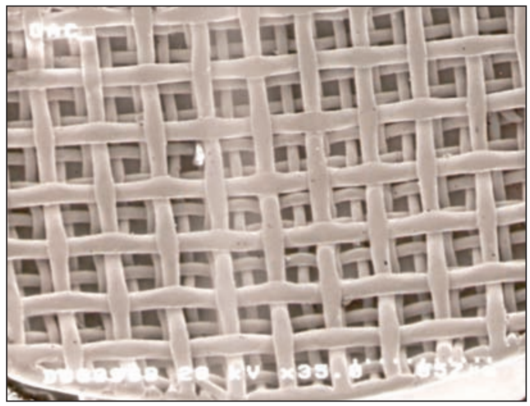
Forty consecutive patients and their parents gave their informed consent to participate in the study. For inclusion, the patients had to be treated with a two-arch fixed appliance system and have no caries or restorations on the buccal surfaces of the teeth to be bonded. There was no restriction on the type of malocclusion.

The patients were randomly assigned to either Group SC (SmartClip, 3M Unitek, Monrovia, CA, USA) or Group IR (In-Ovation R, GAC International, Bohemia, NY, USA). There were 20 patients in each group. The operator was unaware of the group allocation until the patient was ready for direct bonding of the brackets. The SmartClip brackets had a single layer microetched 80 gauge mesh base and the In-Ovation R brackets had a double layer mesh base (microetched 80 gauge over 150 gauge mesh). Scanning electron micrographs of the mesh patterns are shown in Figure 1. Both brackets had similar dimensions, including the bucco-lingual profiles and the surface areas of the bases (Figure 2). The slot size of both systems was 0.022 inch.

One operator used the same procedures to directly bond the brackets to all teeth, excluding the molars. The teeth were cleaned with a rubber cup and pumice slurry, rinsed with water, isolated and dried with oil-free air. The molars were bonded with buccal tubes and excluded from the study. The teeth were primed

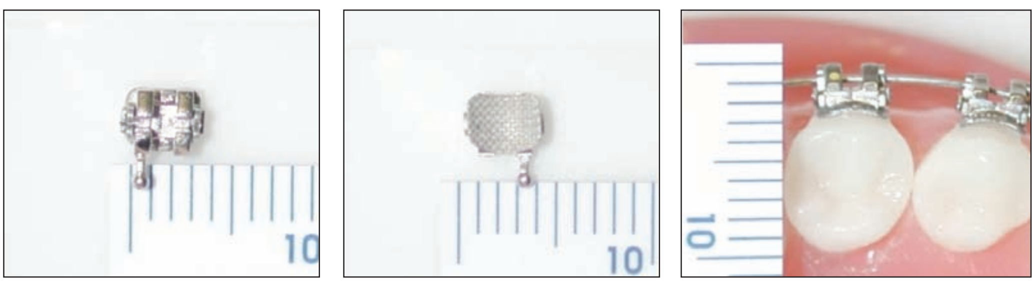


(a)

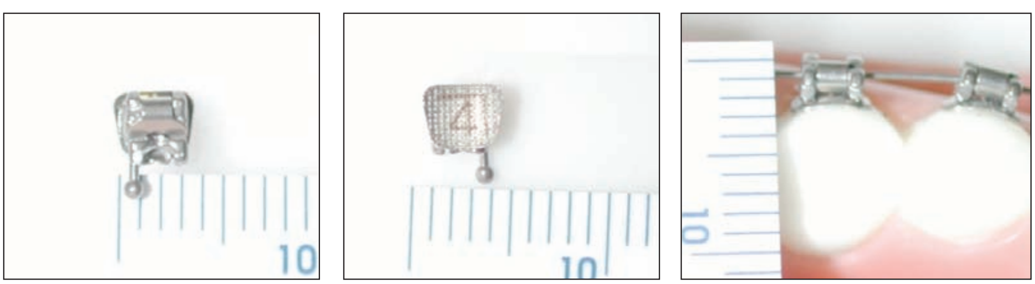


(b)

Figure 1. SEM images of the retentive mesh designs of the brackets. (a) SmartClip bracket (SC), single 80 gauge mesh. (b) In-Ovation R bracket (IR), double layer mesh 80 gauge over 150 gauge. Original magnification 35x.



(a)



(b)

Figure 2. The brackets tested. (a) SmartClip bracket. (b) In-Ovation R bracket.

with Transbond Plus Self Etching Primer (3M Unitek, Monrovia, CA, USA) according to the manufacturer's instructions. Transbond Plus Color Change Adhesive (3M Unitek, Monrovia, CA, USA) was used to attach all brackets. The adhesive was applied to the bracket base and the bracket positioned on the tooth with moderate pressure. Excess adhesive was removed with a sharp scaler. The adhesive was polymerised with a visible light-curing unit (Fusion, DentLight Inc., Richardson, TX, USA) with an output of 1500 mW/cm^2. The tip of the curing light was placed on the mesial edge of the bracket for five seconds and on the distal edge of the bracket for another five seconds.

Initial 0.014 inch NiTi archwires (Sentalloy, GAC International, Bohemia, NY, USA) were placed in both arches, approximately 5 minutes after complete bonding. If any brackets were in occlusion, bonded bite planes (Ultra Band-Lok, Reliance Orthodontic Products, Itasca, IL, USA) were used on the molars to prevent premature bond failure. All patients were given both verbal and written instructions about the care of their appliances, dietary advice and oral hygiene. Patients were also instructed to check for loose brackets daily, and to immediately inform the clinic of any loss and return for the tooth to be rebonded. The tooth/teeth debonded and the date of debonding were recorded. Only first bond failures were noted for each tooth. If patients were unaware of a bond failure or had omitted to call ahead of the scheduled visit, the bond failure was recorded for the day of the visit. Patients were seen every 6 weeks for 12 months, and patients in both groups were treated with the same sequence and progression of archwires.

The survival rates of the brackets were estimated using the Kaplan-Meier test and the survival curves (bracket type, anterior/posterior, maxillary/mandibular) were plotted. Bracket survival distributions were compared using the log-rank and chi-squared tests. The 5 per cent significance level was used.

Results

During the first 6-month period, two (0.5 per cent) brackets in the Group SC failed, and 11 (2.8 per cent) brackets in Group IR failed (Table I). The failure rates were significantly different ($\chi^2 = 6.1$, $p = 0.014$). During the second 6-month period, one (0.3 per cent) SC bracket failed and one (0.3 per cent) IR bracket failed. For the overall 12-month observation period, three (0.8 per cent) SC brackets failed, and twelve (3.1 per cent) IR brackets failed. The 12-month group difference was significantly different ($\chi^2 = 5.2$, $p = 0.022$) and the overall failure rate for both groups was 2.0 per cent.

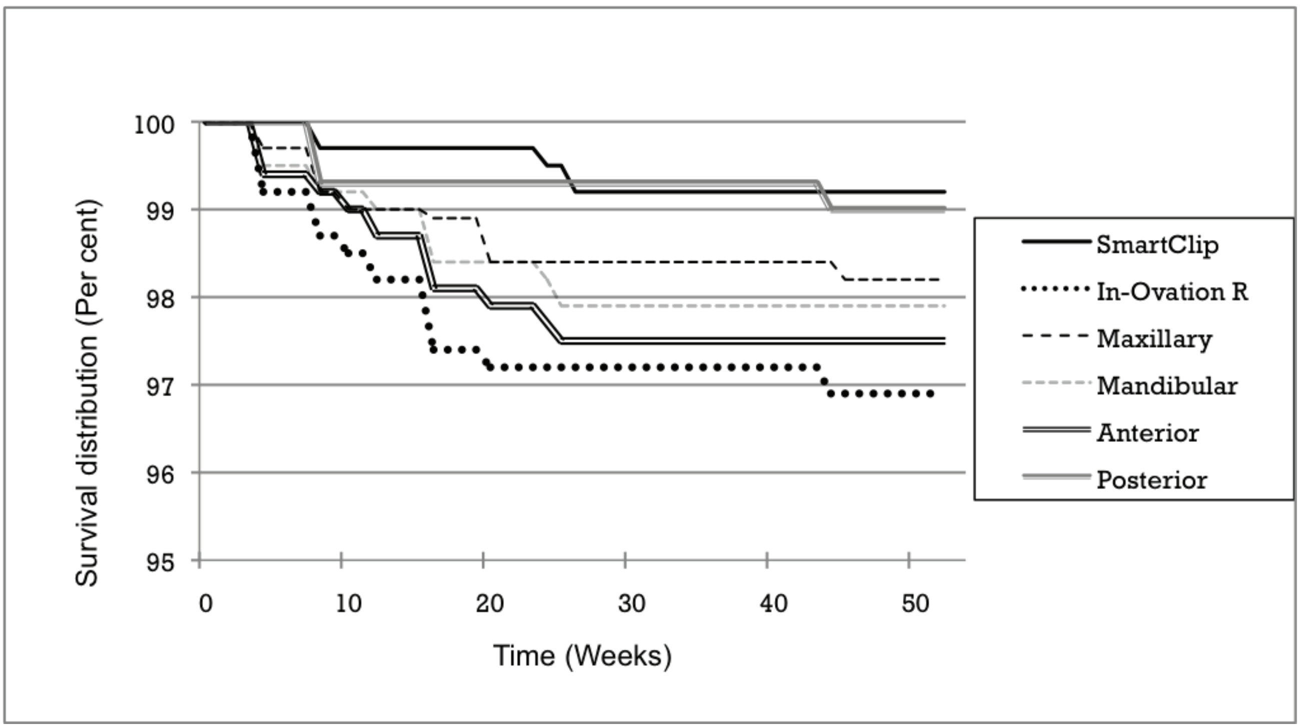


Figure 3. Bracket survival distribution curves plotted with the Kaplan-Meier estimates.

Table I. Bond failure rates for the bracket systems.

	SmartClip			In-Ovation R				
	Survived	Failed	Failure rate (Per cent)	Survived	Failed	Failure rate (Per cent)	*p* Chi-squared	Log rank
First 6-month period	375	2	0.5	378	11	2.8	**0.014**	
Second 6-month period	374	1	0.3	377	1	0.3	NS	
Entire 12-months	374	3	0.8	377	12	3.1	**0.022**	**0.022**

Significant values in bold
NS, not significant

The overall bracket failure rate for the first 6-month period (1.7 per cent) was significantly greater than the second 6-month period (0.3 per cent) (p = 0.005). The bracket survival curves for the 12-month period were plotted using the Kaplan-Meier estimate (Figure 3). The bracket type significantly influenced the survival rate (hazard ratio, 0.25; 95 per cent CI, 0.07 - 0.90; log rank test, p = 0.022). The probabilities of the brackets remaining in place over 12 months were 0.992 for Group SC and 0.969 for Group IR.

The bond failure rates were 1.8 per cent for the maxillary arch and 2.1 per cent for the mandibular arch (Table II). The inter-arch difference was not significantly different (log rank test, p = 0.802; hazard ratio, 0.88; 95 per cent CI, 0.32 - 2.44). The probabilities of the maxillary brackets remaining in place after 12 months was 0.982 and for mandibular brackets it was 0.979. The influence of the dental arch (i.e. maxillary or mandibular) on the bracket survival rate is shown in Figure 3.

The bond failure rate of the anterior brackets over 12 months was 2.5 per cent, and for the posterior brackets it was 1.0 per cent (Table II). There was no statistical difference between the failure rates of the anterior and posterior brackets (log rank test, p = 0.158; hazard ratio, 2.42; 95 per cent CI, 0.68 - 8.69). The probabilities of the anterior brackets remaining bonded after 12 months was 0.975 and for the posterior brackets it was 0.990. The influence of arch location (i.e. anterior or posterior) on the bracket survival rate is shown in Figure 3.

Discussion

In the first six months of this study the bond failure rate of the SC brackets was 0.5 per cent and the failure rate for the IR brackets was 2.8 per cent. This difference was statistically significant. After 12 months the failure rates of the SC and IR brackets increased to 0.8 per cent and 3.1 per cent, respectively. Again, the group difference was statistically significant. It was found that both appliance systems had bracket failure rates below the generally accepted value of 10 per cent and can be considered clinically acceptable.[13,14] Because even small numbers of bracket failures can delay the progress of treatment for some patients, the better survival rates of the SC brackets suggest that it may achieve treatment goals more quickly than the IR bracket.

There was a significantly greater failure rate in the first six months (1.7 per cent) than in the second six months (0.3 per cent). This agrees with previous studies, which concluded that bond failures are more likely to occur within six months of bonding as compared with the second 6-month period.[15-17] It is possible that an imperfect bonding technique or a deficient clinical bonding protocol will lead to weaker bonds that will fail during the initial period of treatment. Also, during the first 6-month period, patients learned which foods they could eat without dislodging their appliances. This early experimentation may have lead to several bond failures. Some brackets may have been subjected

Table II. Bond failure rates for the maxillary and mandibular arches and anterior and posterior teeth.

	Survived	Failed	Failure rate (Per cent)	*p* Chi-squared	Log rank
Maxillary	375	7	1.8		
Mandibular	376	8	2.1	0.802	NS
Anterior	467	12	2.5		
Posterior	284	3	1.0	NS	0.158

NS, not significant

to occlusal forces in the earlier stages of treatment due to bracket placement and a deep bite before levelling and aligning were achieved.

In agreement with previous studies, similar bond failure rates occurred in the maxillary (1.8 per cent) and mandibular (2.1 per cent) arches.[14,15] In the present study the failure rates of brackets bonded to the anterior (2.5 per cent) and posterior (1.0 per cent) teeth were also similar. Cal-Neto et al. and Elekdag-Turk et al. provided data that suggested that higher failure rates were associated with posterior teeth.[13,17] Because the overall bond failure rate in the present study was very low (2.0 per cent), significant differences were difficult to detect.

The SC and IR brackets had different retentive mesh designs. The SC bracket had a single layer 80 gauge mesh base; the IR bracket had a micro etched 80 gauge over 150 gauge mesh. The design of the retentive mesh can affect penetration of the mesh by the adhesive. Previously, Wang et al. reported that mesh bases with large spaces had higher bond strengths.[7] The higher bond strengths were attributed to large mesh bases (80 and 100 mesh sizes) compared with a base with a smaller mesh (70 mesh size) and the extent to which the adhesive penetrated the mesh. Highly filled adhesives may not penetrate small mesh spaces. Sharma-Sayal et al. reported the shear bond strengths of brackets bonded to bovine incisors increased as they moved from 60 gauge to 80 gauge to 100 gauge mesh bases.[9] Smith and Reynolds evaluated the performance of fine mesh, coarse mesh and undercut bracket bases.[10] It was found that the fine mesh base had a higher tensile bond strength than the coarse mesh base, and both mesh bases performed better than an undercut base. Bishara et al. reported that there was no difference in the shear bond strength of double and single mesh brackets.[8] The brackets with a single layer mesh base had a lower failure rate than the double mesh base brackets in the present study. The double layer mesh of the IR bracket may have limited penetration of the highly filled adhesive into the retentive design, leading to more failures than the single layer mesh. However, both bracket systems in the present study produced relatively reliable bonds and clinically acceptable bond failure rates.

The wire diameter and mesh spacing determine the number of openings per unit area of the bracket base. The penetration of adhesive into the retentive design is also determined by the free volume between the mesh and the base and the escape of air during adhesive application.[7,18] Knox et al. determined the tensile bond strengths of single and double mesh bases with 60, 80 and 100 gauge meshes using different adhesives and cements.[12] Successful bonds were attributed to the combination of adhesive and mesh, as some adhesives penetrated certain base designs better than others.

Conclusions

Both the SC bracket and IR brackets produced clinically acceptable bond failure rates.

The SC brackets with single 80 gauge mesh bases had a statistically significant lower bond failure rate than the IR brackets with double layer mesh bases.

Corresponding author

Dr J. Luke Chapman
Private Practice
525 E. Main St
Ville Platte, LA 70586
United State of America

Email: lukechapmandds@yahoo.com
Tel: +337-363-7666
Fax: +337-363-9187

References

1. Rinchuse DJ, Miles PG. Self-ligating brackets: present and future. Am J Orthod Dentofacial Orthop 2007;132:216-22.
2. Pellegrini P, Sauerwein R, Finlayson T, McLeod J, Covell Jr DA, Maier T, Machida CA. 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;135:426.e1-9.
3. 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.
4. Bishara SE, Olsen ME, Damon P, Jakobsen JR. Evaluation of a new light-cured orthodontic bonding adhesive. Am J Orthod Dentofacial Orthop 1998:114:80-7.
5. Nemeth BR, Wiltshire WA, Lavelle CL. Shear/peel bond strength of orthodontic attachments to moist and dry enamel. Am J Orthod Dentofacial Orthop 2006;129:396-401.
6. MacColl GA, Rossouw PE, Titley KC, Yamin C. The relationship between bond strength and orthodontic bracket base surface area with conventional and microetched foil-mesh bases. Am J Orthod Dentofacial Orthop 1998;113:276-81.
7. Wang WN, Li CH, Chou TH, Wang DD, Lin LH, Lin CT. Bond strength of various bracket base designs. Am J Orthod Dentofacial Orthop 2004;125:65-70.
8. Bishara SE, Soliman MM, Oonsombat C, Laffoon JF, Ajlouni R. The effect of variation in mesh-base design on the shear bond strength of orthodontic brackets. Angle Orthod 2004;74:400-4.

9. Sharma-Sayal SK, Rossouw PE, Kulkarni GV, Titley KC. The influence of orthodontic bracket base design on shear bond strength. Am J Orthod Dentofacial Orthop 2003;124:74-82.
10. Smith NR, Reynolds IR. A comparison of three bracket bases: an in vitro study. Br J Orthod 1991;18:29-35.
11. Cucu M, Driessen CH, Ferreira PD. The influence of orthodontic bracket base diameter and mesh size on bond strength. SADJ 2002;57:16-20.
12. Knox J, Hubsch P, Jones ML, Middleton J. The influence of bracket base design on the strength of the bracket-cement interface. J Orthod 2000;27:249-54.
13. Cal-Neto JP, Quintão CA, Almeida MA, Miguel JA. Bond failure rates with a self-etching primer: a randomized controlled trial. Am J Orthod Dentofacial Orthop 2009;135:782-6.
14. Mavropoulos A, Karamouzos A, Kolokithas G, Athanasiou AE. In vivo evaluation of two new moisture-resistant orthodontic adhesive systems: a comparative clinical trial. J Orthod 2003;30:139-47.
15. O'Brien KD, Read MJ, Sandison RJ, Roberts CT. A visible light-activated direct-bonding material: an in vivo comparative study. Am J Orthod Dentofacial Orthop 1989;95:348-51.
16. Aljubouri YD, Millett DT, Gilmour WH. Six and 12 months' evaluation of a self-etching primer versus two-stage etch and prime for orthodontic bonding: a randomized clinical trial. Eur J Orthod 2004;26:565-71.
17. Elekdag-Turk S, Cakmak F, Isci D, Turk T. 12-month self-ligating bracket failure rate with a self-etching primer. Angle Orthod 2008;78:1095-100.
18. Maijer R, Smith DC. Variables influencing the bond strength of metal orthodontic bracket bases. Am J Orthod 1981;79:20-34.