ORIGINAL ARTICLE

The influence of orthodontic bracket base design on shear bond strength

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Many bracket base designs and adhesive materials are in clinical use today. Bases have evolved from perforated metal bases to the present foil mesh bases, and treatments range from none, to spraying metal alloy onto the base, to the most common treatment of microetching. The purpose of this study was to determine the effect of orthodontic bracket base design on mean shear bond strength 1 hour or 24 hours after bonding. For each time group, 12 specimens of 6 types of metal brackets were bonded to bovine incisors with Transbond XT (3M Unitek, Monrovia, Calif) light-cured composite resin. Brackets were debonded 1 hour or 24 hours later, and the shear bond strength was recorded. Six debonded brackets of each type from each time group were selected at random and sandblasted. All the teeth were cleaned, and half were rebonded with used brackets, and half were rebonded with new brackets. Bond strength was measured again, 1 hour or 24 hours later. Representative specimens were inspected under the scanning electron microscope. Bracket base design significantly affected mean shear bond strength. Speed (60-gauge, microetched foil-mesh base; Strite Industries, Cambridge, Ontario, Canada) had the highest bond strength at 1 hour; followed by Time (machined, integral, microetched base with mechanical undercuts; American Orthodontics, Sheboygan, Wis); American Master Series (80-gauge foil-mesh base; American Orthodontics); Ovation Roth (80-gauge layered onto 150-gauge, microetched foil-mesh base; GAC, Central Islip, NY); Orthos Optimesh XRT (100-gauge microetched foil-mesh base; Ormco, Orange, Calif); and, finally, the nickel-free brackets (injection molded, 100-gauge, microetched, foil-mesh base; World Class Technology, McMinnville, Ore). The 24-hour results were similar except that Time had the highest mean shear bond strength (ANOVA, $P < .05$). Chairside sandblasting significantly affected the 1-hour, but not the 24-hour, mean shear bond strengths (ANOVA, $P < .05$). Sandblasting appears to be an effective method of cleaning bracket bases before rebonding. (Am J Orthod Dentofacial Orthop 2003;124:74-82)

Because most bracket bases do not chemically bond to enamel or resin, efforts have been made to improve mechanical retention with various designs. Many bracket base designs are available for clinical use. The increasing demand for a more esthetic metal bonded appliance has led to, among other things, a reduction in the size of the brackets and their bases.[1] The smaller retentive area of the bracket base becomes a variable that influences bond strength. Other important variables affecting bond strength include conditioning procedure, type of adhesive, bracket base design, and treatment of the bracket base.

A variety of reconditioning techniques has been reported. These techniques, imperative in maintaining adequate bond strength, are used after intentional debonding by the clinician to obtain a more appropriate bracket position, or when unintentional traumatic debonding occurs. The techniques include the use of a green stone or carbide bur in a slow handpiece, a periodontal scaler, sandblasting, and thermocycling.[2-8]

Sandblasting uses a high-speed stream of aluminum oxide particles, propelled by compressed air; it can be done at chairside.[9-11] It is also the technique that is least likely to damage the bracket base. The results of studies reported in the literature in which shear bond strength (SBS) values are compared before and after sandblasting are equivocal. Some investigators have reported that rebond SBS values were higher after sandblasting, but others reported no significant differences.[6,7,9,12]

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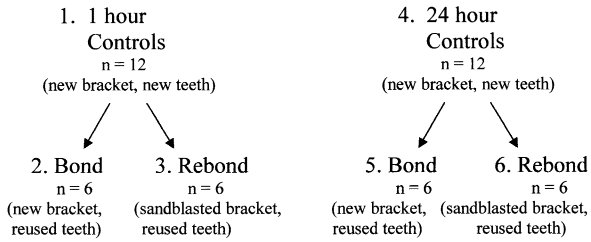

Fig 1. Experimental protocol.

Other investigators have concluded that sandblasting had no consistent effect.[8]

There is a lack of consensus regarding the effect of bracket base design on SBS when tested under conditions simulating clinical use of those brackets.

It is a common practice in clinical orthodontics to insert archwires within an hour of initial bonding, when the cement might not be completely polymerized, thereby increasing the potential for bond failure. Traditionally, laboratory testing of bond strengths is carried out after 24 hours[13-18] or 7 days.[19-22]

The purposes of the present study were (1) to compare the SBS values of 6 different types of stainless steel brackets 1 hour and 24 hours after bonding, (2) to compare the SBS values of reused sandblasted brackets with a new bracket over the same time intervals on the same teeth, (3) to compare the average time taken to sandblast the cement from each type of bracket base to assess whether reusing a bracket is an efficient and economical use of clinical chairside time, and (4), with a scanning electron microscopic (SEM), to assess whether the adherent cement had been effectively removed by sandblasting and whether any significant damage to the bracket base had occurred during this process.

MATERIAL AND METHODS

A bovine tooth model, developed in this laboratory for bond strength testing, was used in this study.[23-25]

The experimental protocol is outlined in Figure 1. Groups of 12 specimens were used for each bracket type and test period. After SBS testing at 1 hour or 24 hours, 6 brackets were selected at random and sandblasted to remove any cement. The enamel surfaces of the bovine teeth were then reprepared and randomly divided into 2 groups of 6. To the teeth of 1 group, a sandblasted bracket was recemented, and, to the teeth of the other group, a new bracket was cemented. SBS testing was again carried out at 1 hour or 24 hours.

Maxillary left central incisor metal brackets were used in this study: (1) Speed (Strite Industries, Cambridge, Ontario, Canada), consisting of a 60-gauge, microetched foil-mesh base with horizontal and vertical configuration; (2) Time (American Orthodontics, Sheboygan, Wis), of machined integral origin, having a microetched base with mechanical undercuts; (3) American Master Series, with 80-gauge mesh of random configuration (American Orthodontics); (4) Orthos Optimesh XRT (Ormco, Orange, Calif), consisting of a 100-gauge foil-mesh base of horizontal and vertical configuration with metal alloy sprayed onto the base; (5) Ovation Roth metal bracket (GAC, Central Islip, NY) with an 80-gauge layered onto 150-gauge microetched foil-mesh base with diagonal configuration and metal alloy sprayed onto the base (supermesh); and (6) nickel-free (Ni-free) 1-piece injection molded bracket with a 100-gauge microetched mesh base of horizontal and vertical configuration (World Class Technology, McMinnville, Ore). The mean base surface area of each bracket type was calculated from 6 randomly selected brackets using a morphometric computer program (Digitek Image Processing System, series 100, Digitek, Brooklyn, NY). A single-paste visible light-cured orthodontic adhesive system, Transbond XT (3M Unitek, Monrovia, Calif), and an unfilled light-cured bonding resin, Heliobond (Vivadent/Ivoclar, St. Catherines, Ontario, Canada), were used in this study.

Bovine incisors obtained from a slaughterhouse were decoronated. After the removal of the coronal pulps, the crowns were frozen in distilled water and stored in a freezer at −20°C until used in accordance with a protocol developed in this laboratory.[26] When needed, the teeth were thawed in warm water, the pulp chambers filled with water soaked cotton pledgets, and embedded in autopolymerizing polymethyl methacrylate in molds (25 mm in diameter × 20 mm deep) so that the labial surfaces were exposed. After polymerization of the polymethyl methacrylate, the teeth were stored in distilled water to which crystals of thymol were added to inhibit bacterial growth.[27] Before bonding, the middle third of the labial surface was flattened sequentially with #180 and #600 grit sandpaper (Buehler Ltd, Lake Bluff, Ill) on a water-irrigated grinding wheel. This same procedure was used to remove the resin after SBS testing and before rebonding new or sandblasted brackets.

The flattened enamel surface was dried with hot air and etched for 20 seconds with a 37% phosphoric acid gel (Reliance Orthodontic Products, Itasca, Ill) and rinsed for 20 seconds with distilled water. The conditioned surface was then dried for 30 seconds with the air dryer. A thin layer of Heliobond was brushed onto this conditioned surface and cured for 10 seconds with a VLC unit (Cure Rite, Caulk Dentsply, L. D. Caulk

Division, Milford, Del). Transbond XT was placed on the bracket base and the bracket placed on the sealed enamel surface so that the slot was parallel to the incisal edge of the incisor. The guide pin of a semiadjustable Hanau articulator (Teledyne Hanua, Buffalo, NY), with a stone cylinder weighing 610 g attached to its upper member, was positioned to engage the bracket slot. This ensured that the bracket was seated under constant pressure and allowed the investigator to remove, with a sharp dental explorer, any surplus extruded cement from the periphery of the base without compromising the onset of the polymerization process. The cement was then cured at 400 MW/cm^2 for 40 seconds (10 seconds for each side of the bracket). The groups of teeth that were to be debonded after 1 hour were stored in distilled water at room temperature, and those that were to be debonded at 24 hours were stored in distilled water with thymol in an incubator at 37°C.

The embedded tooth and its cemented bracket were positioned in a universal testing machine (model 4301, Instron, Canton, Mass) so that the bracket slot was parallel to the horizontal. A sharpened chisel blade was placed at the bracket base-enamel interface, and, using a load cell of 1 kilonewton and a crosshead speed of 0.5 mm/min, the bracket was shear tested to failure. The force producing failure was recorded in newtons and converted into force per unit area (MPa) by dividing the measured force values by the mean surface area of the brackets.

Sandblasting was carried out with a portable sandblasting unit (Danville Engineering, Danville, Calif) using 50 μm aluminum oxide abrasive powder at 3 mm from the bracket base. To ensure a constant distance of 3 mm, 2 pieces of stainless steel orthodontic wire were measured and taped to the tip of the sandblasting handpiece. The total time taken to clean each bracket was recorded, and, from this, the mean was calculated. Each bracket was checked periodically under a light microscope (magnification 25×) to ensure that cement removal was complete. Before rebonding, the brackets were agitated in acetone and dried with compressed air. New bases were sandblasted for the mean time taken to remove the cement from each type of bracket to ascertain whether sandblasting damages the bracket base.

Brackets from which cement had been sandblasted and new brackets, whose bases had been sandblasted for the mean time recorded for removing cement, were selected randomly and prepared for SEM examination. The brackets were stored in absolute alcohol for 24 hours and then mounted on SEM stubs so that the base could be viewed. The specimens were viewed and photographed at magnifications of 25×, 35×, 100×, and 500× with a Hitachi-S 2500 SEM (Hitachi, Mito City, Japan) at an operating voltage of 10 kV.

Table I. Mean surface area of brackets

Bracket type	*Mean surface area (mm^2)*
Speed	7.44
American Master	11.58
Ni-free	11.89
Ormco	12.74
Time	13.14
GAC	13.86

Statistical analysis of the data (SAS system, program GLM, version 6.23, 1996, Cary, NC) included calculating the mean SBS and SD for each group. A 1-way analysis of variance (ANOVA) was carried out to analyze the effect of bracket base design on mean SBS. The effect of time on mean SBS was analyzed with a 2-way ANOVA, with bracket type and time as the factors. A 2-way ANOVA was also performed to determine the effect of chairside sandblasting on mean SBS, with bracket type and sandblasting as the factors. Multiple pairwise comparisons were performed with the Duncan multiple range test. If a significant interaction occurred between factors, the main effects were retested at each level of the factors using the least squares test. Statistical significance was set at $P = .05$.

RESULTS

The mean surface area of each bracket type as determined by the morphometric computer program is shown in Table I. The mean SBS of the control, bonded (new bracket), and rebonded (sandblasted brackets) groups are given in Table II. The range of mean SBS obtained indicates that certain bracket base designs behave differently under the same conditions. The results show that, in general, Speed and Time brackets had the highest mean SBS values and that SBS increased over a 24-hour period. Furthermore, rebonded brackets had higher mean SBS values than did bonded brackets.

The Duncan multiple range test showed that the mean SBS values of the control groups at 1 hour are clustered into 3 groups (Fig 2). The first group includes Speed and Time; the second, American Master, Ormco, and GAC; and the third, Ni-free. There were no in-group statistically significant differences, but the 3 groups were statistically significantly different from each other ($P = .0001$). At 24 hours, the groupings were similar (groups A, B, C, and D) to the 1-hour group, except that Time (group A) had a higher mean SBS than Speed (group B), and this difference was statistically significantly different ($P = .01$) (Fig 3).

Table II. Mean SBS values

Group	*Bracket type*	*Material*	*Surface treatment of teeth*	*Treatment of bracket base*	*n*	*1 hr MPa ± SD*	*24 hrs MPa ± SD*
Control (new bracket, new teeth)	Speed	Transbond XT	Etched (37% PA)	None	12	6.76 ± 1.30	8.05 ± 2.75
	Time	Transbond XT	Etched (37% PA)		12	5.98 ± 0.68	9.73 ± 1.64
	American Master	Transbond XT	Etched (37% PA)		12	4.14 ± 0.98	2.20 ± 1.75
	Ormco	Transbond XT	Etched (37% PA)		12	4.14 ± 1.19	5.25 ± 2.04
	GAC	Transbond XT	Etched (37% PA)		12	3.38 ± 1.00	4.47 ± 1.21
	Ni-free	Transbond XT	Etched (37% PA)		12	2.13 ± 0.98	2.21 ± 0.51
Bonded (new bracket, reused teeth)	Speed	Transbond XT	Excess cement removed, with 180 and 600 grit sandpaper on irrigated grinding wheel then etched (37% PA)	None	6	5.90 ± 0.82	7.10 ± 1.89
	Time	Transbond XT			6	6.39 ± 1.51	8.96 ± 1.77
	American Master	Transbond XT			6	3.93 ± 0.50	3.97 ± 0.73
	Ormco	Transbond XT			6	3.48 ± 1.16	4.50 ± 0.87
	GAC	Transbond XT			6	3.17 ± 0.34	4.31 ± 1.61
	Ni-free	Transbond XT			6	2.37 ± 0.63	2.30 ± 0.53
Rebonded (sandblasted bracket, reused teeth)	Speed	Transbond XT	Excess cement removed, with 180 and 600 grit sandpaper on irrigated grinding wheel then etched (37% PA)	Sandblasted*	6	6.22 ± 1.93	7.89 ± 2.07
	Time	Transbond XT			6	8.06 ± 2.09	11.24 ± 2.55
	American Master	Transbond XT			6	4.69 ± 1.17	5.36 ± 1.70
	Ormco	Transbond XT			6	3.80 ± 0.67	3.86 ± 0.85
	GAC	Transbond XT			6	3.67 ± 1.41	3.38 ± 1.08
	Ni-free	Transbond XT			6	2.58 ± 0.88	3.15 ± 1.22

PA, phosphoric acid.
*50 μm aluminum oxide at 3 mm.

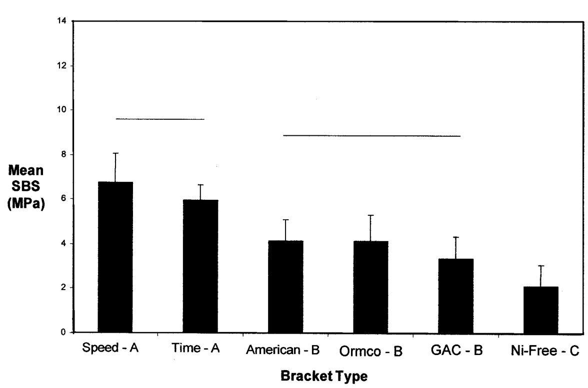

Fig 2. Mean SBS values (MPa) of controls at 1 hour (n = 12); Duncan multiple range test grouping shown as *A*, *B*, and *C* after bracket label.

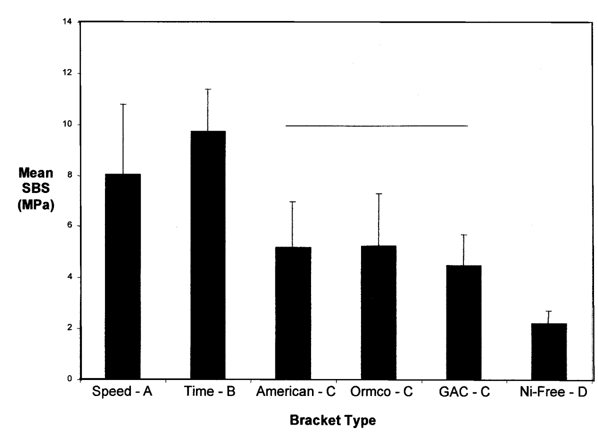

Fig 3. Mean SBS values (MPa) of controls at 24 hours (n = 12); Duncan multiple range test grouping shown as *A*, *B*, and *C* after bracket label.

In general, the mean SBS values for all 6 bracket types increased with time. For all bracket base types, the mean SBS values were 4.42 MPa at 1 hour and 5.82 MPa at 24 hours, an increase of 24%. Of all these increases, the mean SBS values of Speed (P = .03) and Time (P = .0001) brackets were statistically significant. Over 24 hours, the mean increases in SBS values of Speed and Time were 16% and 9%, respectively.

In general, the mean SBS values after 1 hour increased for all 6 bracket types after sandblasting and rebonding; these increases were significant (P = .03). The means were 4.21 MPa for bonded brackets and 4.84 MPa for sandblasted brackets, an overall increase of 15%. The only statistically significant increase was

Table III. Mean sandblasting times for all brackets

		Sandblasting time (seconds) ± SD		
Bracket type	*n*	*1 hour*	*24 hours*	P *value*
Speed	6	47.67 ± 25.41	39.17 ± 19.69	.85
Time	6	228.67 ± 73.65	308.83 ± 190.20	.04*
American Master	6	57.17 ± 8.98	64.33 ± 10.95	.85
Ormco	6	54.83 ± 7.91	39.17 ± 6.18	.68
GAC	6	111.67 ± 83.87	105.33 ± 52.56	.87
Ni-free	6	26.33 ± 8.71	27.50 ± 5.58	.98

*Statistically significant difference ($P < .05$).

the mean SBS of the Time bracket ($P = .02$). Sandblasting had no significant effect on the mean SBS after 24 hours ($P = .09$). The mean for bonded brackets was 5.19 MPa, an overall increase of 12%. Again, the Time bracket proved to be the exception, with a statistically significant mean increase in SBS ($P = .01$).

The effects of sandblasting were similar for all bracket types: mean SBS values increased after sandblasting. Thus, there was no significant interaction between bracket base design and sandblasting at 1 hour ($P = .70$) or at 24 hours ($P = .11$). Specific interactions were noted, however, when comparing sandblasting with specific base designs. Before sandblasting, the mean SBS values of Speed and Time brackets were not significantly different from each other, although they were significantly different from all other bracket types. After sandblasting, the mean SBS of Time increased more than did that of Speed; this difference was statistically significant ($P < .05$). The mean SBS of the American bracket after sandblasting became significantly higher when compared with GAC and Ni-free ($P < 0.05$). On the other hand, Ormco showed a higher mean SBS before sandblasting than Ni-free ($P < .05$), but there was no significant difference between the after-sandblasting values. GAC and Ni-free showed similar results.

The mean times taken to sandblast the bracket base clean of cement are given in Table III. The Time bracket took statistically significantly much longer to clean than the other 5 types, at both 1 hour and 24 hours ($P = .04$). Overall, however, there was no significant difference in the time taken to clean a bracket of the same type, whether it was debonded at 1 hour or 24 hours ($P = .54$). In general, bracket base design was shown to significantly affect the sandblaster's ability to clean off the cement ($P = .0001$). The results showed that it takes significantly longer to clean a Time bracket base than the other 5 types, and also that a GAC bracket takes longer to clean than a Ni-free bracket.

Speed, American Master, Ormco, and Ni-free brackets all had single-layer mesh bases, which appeared to be fully cleaned of cement after sandblasting. The Speed bracket represents this group (Fig 4). Time bracket bases had rippled ridges that were undercut; although they appeared to be fully free of cement after sandblasting, higher magnifications showed remnants of cement adhering to the undercuts (Fig 5). The GAC brackets had a dual mesh configuration, and, after sandblasting, there appeared to be some damaged areas on the base (Fig 6, *A* and *B*). Sandblasting new GAC brackets for 112 or 105 seconds (the average time to sandblast them free of cement at 1 hour or 24 hours) resulted in similar damaged areas to the dual-mesh base.

DISCUSSION

In the present study, only 1 type of cement was used to ensure that any significant variations in SBS were clearly attributable to variations in bracket base design. The use of constant force in placing the brackets further ensured that the cement lute for all types of brackets was the same thickness.[23] It has been determined that the minimum tensile bond strength required by a bracket to resist debonding forces is 2.86 MPa, and, with the exception of Ni-free brackets, the bond strengths recorded in this study exceeded this amount.[28,29] Although SBS values were recorded in this study, it has been shown that there is no significant difference between shear and tensile induced bond failure.[30]

In general, mean SBS values for all bracket types increased over a 24-hour period. If surface area was a factor in this increase, then it could reasonably be expected that Speed brackets, with the smallest base area, would reach maximum SBS almost immediately after initial cure of the cement. The reverse could be expected for Time and GAC brackets. The results, however, showed that Time and Speed brackets had significantly higher SBS at 1 hour and at 24 hours and that the SBS of Time was lower than that of Speed at 1

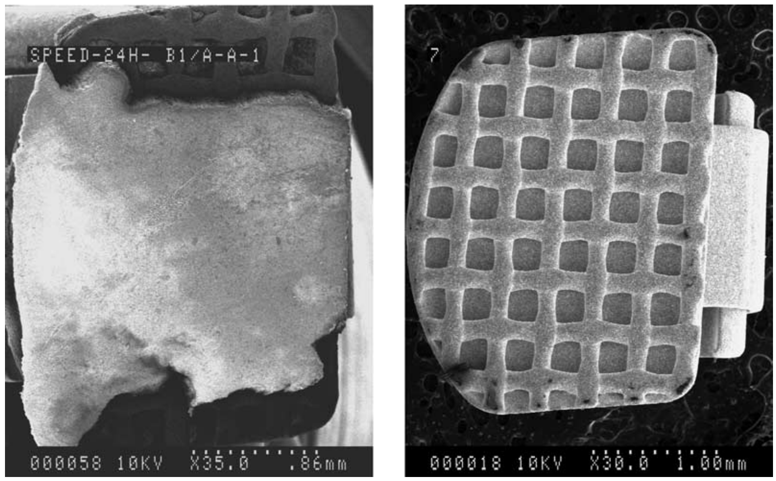

Fig 4. A, SEM view of Speed bracket base with cement; original magnification, 35×. **B**, SEM view of Speed bracket base after sandblasting; original magnification, 30×.

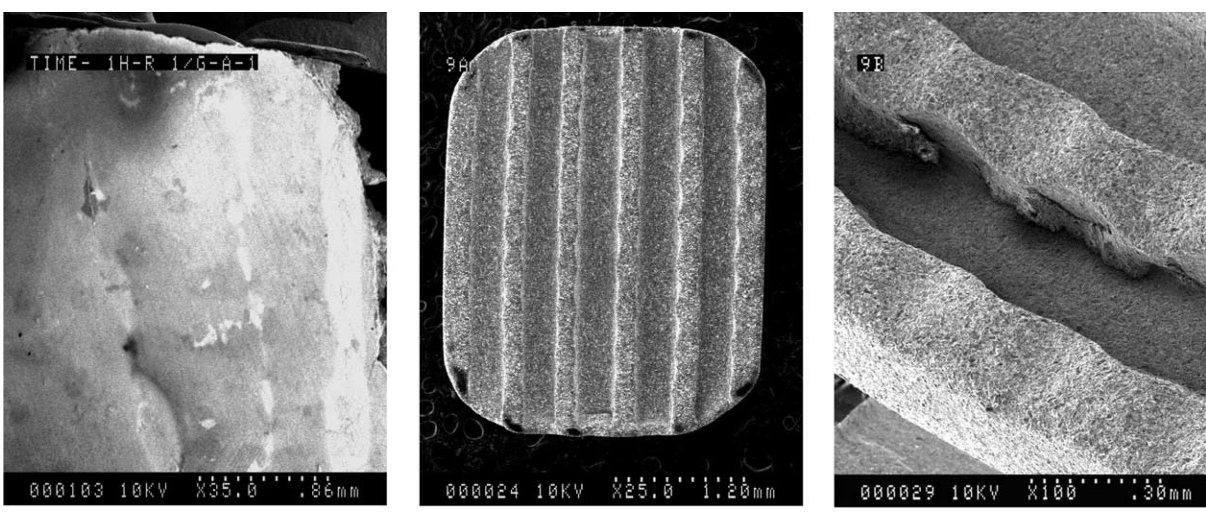

Fig 5. A, SEM view of Time bracket base with cement; original magnification, 35×. **B**, SEM view of Time bracket base after sandblasting; original magnification, 25×. **C**, SEM view of Time bracket base showing cement adhering to undercuts; original magnification, 100×.

hour but higher at 24 hours. GAC was clustered together with American Master and Ormco, but Ni-free was outperformed by all of them.

Examination of the bases shows that Speed brackets have a 60-gauge mesh base and Time an integral microetched base with mechanical undercuts. American Master brackets have 80-gauge nonmicroetched foil mesh bases. Ormco has 100-gauge foil mesh alloy sprayed bases, and GAC has 80-gauge layered on a 150-gauge microetched foil meshed base. The foil mesh is brazed to the bracket body on these latter 3 brackets. In contrast, Ni-free brackets have 100-gauge microetched foil-mesh bases that are contiguous with the bracket body (1-piece injection-molded brackets). The result is a base with very shallow grooves. It is thus probable that the wider mesh of the Speed bracket and the open undercut configuration of the Time bracket allow for more efficient and complete penetration of the cement, resulting in significantly higher bond strengths. On the other hand, foil-mesh gauges of 80, 100, and 150 could restrict penetration of the cement, resulting in lower yet clinically acceptable bond strengths. It would also appear from our results that the shallow mesh configuration of the 1-piece injection-molded Ni-free bracket does not allow adequate penetration of cement for a clinically acceptable bond. Only 1 cement,

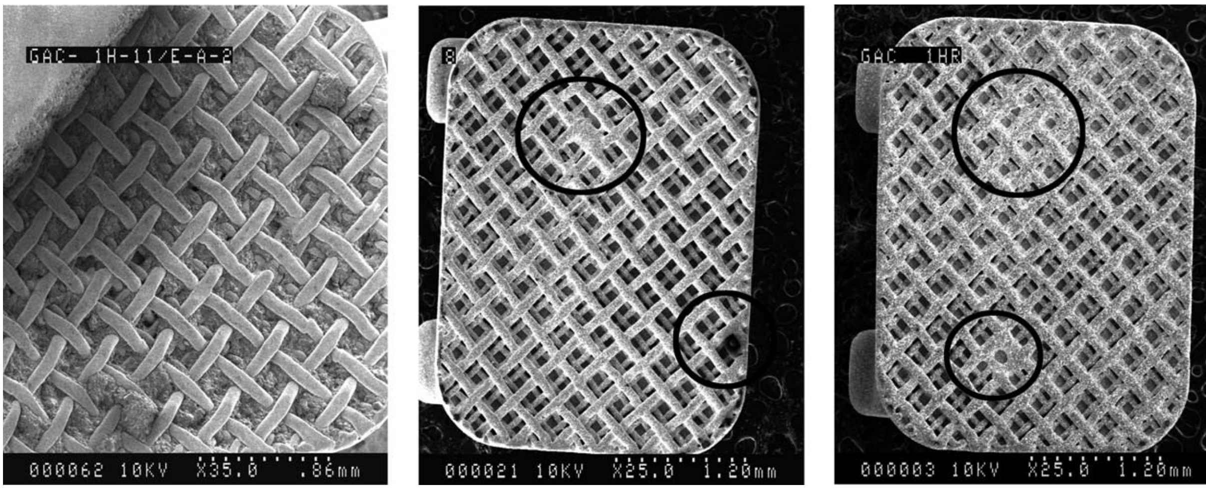

Fig 6. A, SEM view of dual-mesh GAC bracket base; original magnification, 35×. **B**, SEM view of GAC bracket base after sandblasting. Note areas of damage (*circles*); original magnification, 25×. **C**, SEM view of new GAC bracket base after sandblasting. Note areas of damage (*circles*); original magnification, 25×.

Transbond XT, was used to standardize and test the response of the various brackets to this cement. A more liquid cement, having a smaller particle size, could penetrate the grooves and undercuts better and might lead to different results.

It has been reported that the bracket base-cement interface is the weakest point in orthodontic bonding.[5,19,29-34] Bracket base treatments such as microetching to increase surface area have been shown to enhance adhesion, leading to an increase in bond strength.[8,23] Brackets with foil-mesh bases have also been shown to have higher bond strengths than those with integral milled bases such as the Dynalock bracket.[16,17,35,36] The base of the Dynalock bracket was shown to have shallow milled channels that were incompletely filled with adhesive; a suggested improvement for the base was to increase the amount of available undercut.[17] The Time bracket appears to have met these criteria and, as shown in this study, to exhibit superior SBS. Similarly, bond strengths of brackets with integral milled bases were shown to improve when a highly filled resin cement was used.[37] Transbond XT is a highly filled resin cement, and our results support this finding.

In clinical practice, most orthodontists place archwires within 1 hour of bracket cementation. Information about SBS values of various base designs tested 1 hour after bonding thus permits an informed choice of brackets in clinical treatment. The results of this study show that, with the exception of Ni-free brackets, clinically acceptable bond strengths were achieved with Transbond XT cement after 1 hour. It was also shown that, with the exception of the Time bracket, all brackets achieved at least 76% of their final bond strengths after 1 hour. The Time bracket achieved 66% of its final bond strength after 1 hour, and, at 5.98 MPa, this compared very favorably with the clinically acceptable minimum of 2.86 MPa.[28,29] These findings confirm a previous report in which Transbond XT produced bond strengths of sufficient magnitude to withstand orthodontic forces after a 60-minute cure.[38] The laboratory testing of SBS at 1 hour is probably unnecessary because any increase from 1 hour to 24 hours is not significant.

The results of sandblasting and reusing brackets are equivocal. In general, the sandblasted brackets achieved higher SBS values after 1 hour when compared with a new bracket, and, with the exception of GAC, the bond strength increased at 24 hours. These increases were not statistically significant and are similar to others reported.[39] The SBS of Time brackets was significantly increased by sandblasting over both time intervals; similar results have been reported with the integral milled Dynalock bracket.[8]

Factors to consider with sandblasting are the mesh sizes and configurations of the bracket bases; the particle size of both the cement and the sandblasting material; whether the cement can be completely removed; and whether sandblasting damages the base. In this study, the bracket bases were periodically inspected under an SEM at a magnification of 25× to ensure complete cement removal. Subsequent examination showed that, for the most part, the cement had been removed from the foil-mesh bases, but remnants adhered to the undercuts in the rippled ridges of the Time base. Our results indicated that these minimal remnants of cement had no significant effect on SBS except for the GAC bracket, but even the decrease recorded for this bracket was not statistically significant. These results are partially supported by those of a study in which 7 of 12 brackets showed the same or higher bond strengths after sandblasting, and the remaining 5 had lower bond strengths.[8] With the exception of the finer-mesh GAC bracket, sandblasting appeared not to cause any damage to the bracket base. This damage, however, appeared to have no effect on SBS. These data agree with those obtained in a previous study, which indicated that microscopic damage to bracket bases caused by sandblasting did not affect bond strength.[7]

Our results showed that the more complex the design of the bracket base, the longer it took to sandblast it clean of cement. The Time bracket, with its base of undercut, furrowed ridges, required a significantly longer time to sandblast than the foil-mesh base. The mean times for the Time bracket were 3.6 and 5.0 minutes at 1 hour and 24 hours, respectively. The findings were similar for foil-mesh bracket bases. The complex double-mesh GAC bracket took approximately 1.5 minutes to clean, whereas the single-mesh Speed, Ormco, American Master, and Ni-free brackets took between 0.5 and 1.0 minute to clean. These results agree with those of another study that reported that brackets with complex base designs require more time to clean.[39]

These results demonstrate that bracket base design significantly influences SBS and that brackets with a 60-gauge foil-mesh or an integral undercut machined base achieve higher bond strengths. This study further shows that sandblasted brackets can be reliably reused, and, if damage to the bracket base caused by sandblasting is minimal, SBS is not compromised. Ultimately, the clinician must decide whether it is cost effective to reuse a bracket that takes more chairside time to clean and whether the cost of the bracket merits its reuse. These factors, not considered in this study, will vary from practice to practice and clearly influence the clinician's decisions.

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