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Distortion of Metallic Orthodontic Brackets After Clinical Use and Debond by Two Methods

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Abstract: *The objective of this paper was to compare distortion of the tie wings and bases of metallic orthodontic brackets following clinical use and after debond by either of two methods, and took the form of a prospective random control trial. Five-hundred-and-seven brackets were debonded using either bracket removing pliers or a lift off debonding instrument (LODI). By a system of random allocation contralateral opposing quadrants were debonded with a 0·019 × 0·025-inch archwire either in place or removed. After debond brackets were tested for slot closure by the fit of rectangular test wires from 0·016 × 0·022 to 0·021 × 0·025 inch in size. The LODI produced few slot closures sufficient to affect the fit of all but the largest test wire. Bracket removing pliers used after removal of the archwire produced significantly greater numbers of distorted brackets in response to testing with all but the largest wire. With the 0·021 × 0·025 inch wire in place the presence or absence of the archwire at the time of debond made no difference to the number of slot closures. Ten per cent of the brackets debonded using bracket removing pliers had distorted bases, no base damage was produced by the LODI.*

The use of bracket removing pliers at debond caused significantly more slot closures than use of the LODI. When bracket removing pliers are used the archwire should be left in place at the time of debond since this reduces the number of distortions.

Index words: Brackets, Recycling.

Refereed Paper

A recent survey of 300 members of the British Orthodontic Society showed that 48 per cent used metal orthodontic brackets more than once. Recycling was more common amongst specialist practitioners than consultants, 60 per cent as against 25 per cent (Coley-Smith and Rock 1997).

It is probable that the main impetus towards recycling is financial, since some straightwire brackets cost more than £3·00 each. However, when recycled brackets are used in the mouths of patients it is crucial that the clinician has assurance that they are as good as new. This presents quite a challenge since new straightwire orthodontic brackets are manufactured to very tight specifications. The definitive 'A' Company Straight-Wire® brackets (Opident Ltd, Butterfield Dental Centre, Acorn Business Park, Keighly Road, Skipton, North Yorkshire BD23 2UE, UK) are investment cast from plastic patterns. The mould leaves a small depression in each casting into which the slot is milled in a separate procedure. During manufacture an individual bracket may be examined up to seven times. Slot-to-base angle and slot wall parallelism are assessed optically, and slot size is checked using 'Go/No-Go' gauges. A tolerance level of 0·2–0·5 degrees is claimed for tip and torque angulations, and this has been supported by independent research (Tan, 1991). Less than 1 in 1000 brackets sent to a recycling company has been found to have manufacturing flaws (Matasa, 1990).

The tendency to require brackets of ever more complex shapes has lead to the replacement of milling by casting as a manufacturing technique, although slots may be milled into castings as a secondary operation as described above. Cast brackets are somewhat softer than those produced by milling from cold drawn steel and they are therefore more susceptible to damage during clinical usage.

Brackets may be damaged in several ways:

1. By incorrect handling during bonding and banding procedures: in particular, pressure from a band pusher on a tie wing may lead to slot closure.
2. By forces exerted by archwires and elastics: it is unlikely that any force used during orthodontic treatment could deform a metal bracket, but wear facets produced by friction between brackets and archwire have been reported in slot bases after clinical use (Tan, 1991).
3. By occlusal forces: forces as high as 50 kg have been measured between the molar teeth of adults (Lavelle, 1988). Although such a high force might easily deform the wings of a bracket it is more likely that a bonded bracket would be dislodged from the tooth.
4. Corrosion effects: a significant proportion of orthodontic appliance failures have been attributed to corrosion (Matasa, 1995). There is some evidence that commercial recycling may increase the chances of bracket corrosion (Maijer and Smith, 1986).
5. Damage produced during debonding: brackets may be distorted in various ways by the debonding process. Matasa (1989) reported slot closure, base distortion, and damage to tie wings.

Several types of instrument have been used to remove brackets from teeth at the end of treatment.

Bracket removing pliers (Figure 1), which apply a force

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FIG. 1 Bracket removing pliers.

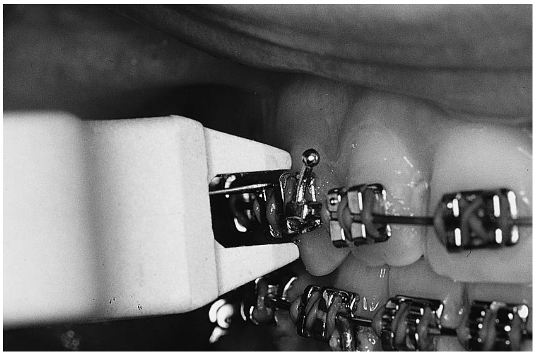

FIG. 2 The Lift-Off Debonding Instrument (LODI).

across the bracket base were used by 66 per cent of American orthodontists in a survey by Gorelick (1979).

Other orthodontic pliers of various types have also been used to remove brackets by squeezing across the tie wings to produce base distortion and thereby bond failure (Artun and Bergland, 1984; Graber and Vanardsdall, 1994; Zarrinnia *et al.*, 1995). The use of pliers in this way inevitably produces distortion of the bracket wings so that the brackets are less suitable for recycling than those debonded using other methods.

Ligature cutters applied across the base of a bracket cause bending, and consequent fracture within the resin or at the resin/enamel interface. This method is considered by some to be the safest, although it has the disadvantage that the distorted bracket cannot be reused (Bennett *et al.*, 1984). Others have expressed concern that enamel damage may be caused by the beaks of ligature cutters used in this way (Oliver, 1988).

The Lift-Off Debonding Instrument (LODI; Figure 2) has a wire loop that engages beneath a tie-wing and applies a shear force when the handles are squeezed. This method has been considered to produce no damage and is recommended if recycling is a consideration (McGuinness, 1992).

Aims of study

The aims of the study were to determine whether or not there were differences in the patterns of bracket distortion after clinical treatment using two different debond methods, and to determine whether debonding with the archwire *in situ* or not affected the results.

Methods

Thirty-two patients treated consecutively by one operator (ACS) formed the study group. Since the study did not affect treatment in any way ethical approval, was not sought.

All patients were treated with 0·022-inch slot 'A' Company upper and lower Straight-Wire® appliances, finishing on 0·019 × 0·025-inch rectangular stainless steel archwires. All brackets were bonded using Right On® (TP Orthodontics, 2 Bruntcliffe Way, Morley, Leeds LS27 OJG, UK) adhesive after etching for 30 seconds. At the conclusion of treatment, appliances were removed from alternate patients using either bracket-removing pliers or the LODI. Using random allocation for the first upper quadrant to be debonded, contralateral upper and lower quadrants were debonded with the finishing archwire in place. The wires were then removed before the two remaining quadrants were debonded. This split mouth technique produced four experimental groups (Table 1).

After debond, all brackets were examined sequentially using a series of rectangular archwires from 0·016 × 0·022 to 0·021 × 0·025 inch to see whether these could be engaged fully into the bracket slot. Distortion and other bracket defects were assessed by examining brackets in reflected light using a binocular microscope at ×40 magnification. Base distortion was recorded as present, if one or more edges of the base were seen to be bent or curled.

Differences in the proportions of brackets that fitted test archwires in the four groups were evaluated using the Chi-squared test.

Results

A total of 507 brackets were debonded from 32 patients. The results obtained by testing brackets for the fit of archwires of increasing size are shown as Table 2. After debond using the LODI, almost all archwires except the largest fitted the slots. However, the 0·021 × 0·025 test wire failed to engage into 41 (33·1 per cent) of brackets debonded with the archwire in place and 24 (19 per cent) of brackets debonded after removal of the archwire (χ^2 = 6·38, $P < 0{\cdot}05$).

Use of bracket-removing pliers with the archwire in place produced no slot closure for any archwire size below the largest. When this was used 57 (44·9 per cent) of brackets failed to accommodate the wire. When the archwire had been removed before debond even the smallest 0·016 × 0·022-inch test wire failed to fit 21 (16 per cent) of brackets, whilst the 0·021 × 0·025-inch test wire fitted only 62 (48 per cent) of brackets. For this last combination of variables bracket-removing pliers produced significantly more slot closures than the LODI (χ^2 = 30·745, $P < 0{\cdot}001$).

TABLE 1 *Debond method and archwire status for the four experimental groups*

Debond method	Upper right	Upper left	Lower right	Lower left
LOD1	In	Out	Out	In
LOD1	Out	In	In	Out
Pliers	In	Out	Out	In
Pliers	Out	In	In	Out

TABLE 2 *Proportions of brackets that were engaged by each size of archwire for each debond technique*

	Debond method													
	LODI: numbers of wires that fitted							Bracket pliers: numbers of wires that fitted						
Archwire status	In			Out				In			Out			
Test wire	Total	Fitted	%	Total	Fitted	%	Sig	Total	Fitted	%	Total	Fitted	%	Sig
16 × 22	124	124	100	126	123	97·6	NS	127	127	100	130	109	84	***
17 × 25	124	124	100	126	123	97·6	NS	127	127	100	130	109	84	***
18 × 25	124	124	100	126	123	97·6	NS	127	127	100	130	106	82	***
19 × 25	124	124	100	126	120	95·2	NS	127	127	100	130	100	76·9	***
21 × 25	124	83	66·9	126	102	81	*	127	70	55·1	130	62	48	NS

χ^2 Values: NS, not significant; *$P < 0{\cdot}05$; ***$P < 0{\cdot}001$.

TABLE 3 *Numbers of test wires of each size that failed to fit the slot*

Archwire size*											Did not fit
16 × 22	0	1	3	0	2	4	1	3	0	2	16
17 × 25	0	1	3	0	2	4	1	3	0	2	16
18 × 25	0	1	4	0	2	4	1	3	0	2	17
19 × 25	0	1	5	0	2	5	1	4	1	2	21
21 × 25	4	5	23	7	11	15	12	13	4	5	100
Total brackets	23	10	32	30	32	32	32	31	11	20	253
Tooth	**5**	**4**	**3**	**2**	**1**	**1**	**2**	**3**	**4**	**5**	
Tooth	**5**	**4**	**3**	**2**	**1**	**1**	**2**	**3**	**4**	**5**	
Total brackets	16	16	32	29	32	31	31	32	16	19	254
21 × 25	6	3	17	8	8	7	10	16	9	6	90
19 × 25	1	1	4	0	1	1	1	4	1	1	15
18 × 25	0	1	3	0	1	1	1	3	0	0	10
17 × 25	0	1	2	0	1	1	0	3	0	0	8
16 × 22	0	1	2	0	1	1	0	3	0	0	8

*Thousandths of an inch.

A breakdown of the numbers of test archwires of each size that failed to fit the bracket slot of each tooth type is shown as Table 3. Canine brackets were most often affected by slot closure and 69 (54 per cent) did not accommodate the 0·021 × 0·025-inch test wire. Thirty-six per cent of all brackets with slot closure to this extent were from canines.

The largest test wire failed to engage 100 upper and 90 lower arch brackets. This difference was not statistically significant ($\chi^2 = 0{\cdot}906$, $P > 0{\cdot}05$).

Distortion of the base was seen on 25 (9·7 per cent) of brackets debonded using bracket removing pliers (Figure 3). No base distortion was associated with use of the LODI.

An incidental finding of the study was the presence of wear facets in the bases of the slots of many brackets. Two-hundred-and-thirty-one (45 per cent) of all brackets showed such wear when examined under the microscope (Figure 4).

FIG. 3 Base distortion caused by bracket removing pliers.

Discussion

An organization that reprocesses medical devices designed primarily for single use must be able to demonstrate that the reused product is safe and has unchanged properties. The number of episodes that constitute safe reuse must have been determined and appropriate records kept (Department of Health, Medical Devices Agency, 1995). From 13th June 1998, regulations were further tightened since devices now require a CE (Conformite Europeenne) marking to indicate that the product conforms to Medical Devices Directive 93/42/EEC.

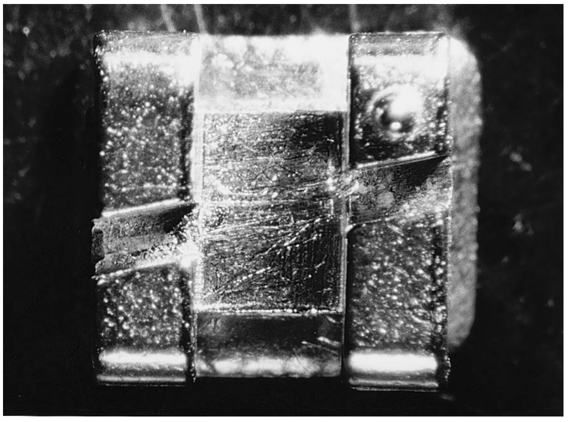

FIG. 4 Examples of wear facets in a bracket.

In the course of bracket recycling, old adhesive is removed by heat or chemical solvents, after which the brackets are cleaned and repolished. The aim of the process must be to produce a bracket, which is to all intents and purposes as good as new so that it can be rebonded to enamel to produce a bond of adequate strength (Postlethwaite, 1992).

It is in the interests of both patient and orthodontist that a reused bracket should not have been adversely affected by clinical use, including the debond procedure and, subsequently, by the recycling process. Even small distortions of tie wings could affect the fit of archwires and in-built values of tip and torque, and the problem may be compounded, since the damage would not become apparent until relatively late in treatment. It is possible that round aligning arches up to 0·016 inch in diameter would engage into quite badly distorted brackets to produce satisfactory initial realignment of displaced teeth, and the difficulties produced by small, but important distortions would only be seen when attempts were made to fit rectangular arches of 0·018 × 0·025 inch and above.

The need to replace a bracket at this relatively late stage of treatment is particularly galling, since it is difficult to place the new bracket with sufficient precision to avoid the need to drop down the archwire sequence as far as a flexible aligning wire to permit correct slot engagement. In consequence treatment time may be extended by 2–3 months.

Table 3 shows the numbers of brackets in each group that were fully engaged by test archwires of various sizes. Since the brackets all had 0·022-inch slots when new, failure of each size of test arch to fit represented slot closure of from 0·006 inch for the 0·016 × 0·022-inch wire to 0·001 inch for the 0·021 × 0·025-inch test wire. For each wire size the greatest proportion of fit failures was found in quadrants debonded using bracket-removing pliers with the archwire removed before debonding. Significantly more brackets in this group failed to accommodate a test wire of each size than did brackets in the other three groups, except when the 0·021 × 0·025-inch wire was used ($P < 0{\cdot}01$).

In the present study all treatments were finished on 0·019 × 0·025-inch archwires. Following debond 36 (7·1 per cent) of the total 507 brackets would not have accommodated an archwire of similar size had they been reused. Thirty of the 36 brackets were from quadrants debonded using bracket-removing pliers with the archwire removed before debond. The results, therefore, suggest that if bracket-removing pliers are to be used and bracket recycling is contemplated, the archwire should be left in place at the time of debond.

The most severe test of bracket slot closure was the 0·021 × 0·025-inch wire and the greatest numbers of fit failures were found in association with this wire. This is not surprising, since a slot closure of only one-thousandth of an inch would be enough to prevent fit of a wire of this size. Around half of the brackets debonded using pliers failed to accommodate the largest test wire and having the 0·019 × 0·025-inch archwire *in situ* at the time of debond made no difference. When the LODI was used with the archwire in place, significantly more brackets were distorted by one-thousandth of an inch than when the archwire was removed before debond. It is possible that the support afforded to the brackets by the 0·019 × 0·021-wire meant that the LODI had to pull more forcefully on a tie wing in order to produce dislodgment of the bracket from the tooth.

The presence of wear facets in the slot bases of many brackets must have been due to contact between the bracket and archwire. The shiny facets showed up clearly against the matt cast surface of the bracket when viewed under the microscope. They suggest that, even with an accurately designed rectangular slot system, actual archwire/bracket contact takes place over a very small area, generally at one or both ends of the slot. The significance of this observation in terms of friction is a topic that will be the subject of further study.

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