European Journal of Orthodontics 29 (2007) i128–i134
doi:10.1093/ejo/cjl079

Direct bonding in orthodontic treatment and retention a post-treatment evaluation

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(Transactions of the European Orthodontic Society 1976, pp. 291–301)

SUMMARY A post-treatment evaluation, after 9-20 months of routine orthodontic therapy, was made on the effectiveness of direct bonding with a chemically polymerized diluted composite material. A total of 612 brackets and buccal tubes on perforated metal backings were bonded to different teeth of 75 patients, including 237 incisors, 125 canines, 164 premolars and 86 first or second molars. To improve aesthetics, oral hygiene and gingival condition, slim bracket bases were used on all teeth and care was taken to use minute quantities of adhesive material. The same investigator bonded all the brackets and performed the orthodontic treatment.

The results demonstrated an overall failure rate of 11 per cent for the whole treatment period. The brackets most prone to come loose were the maxillary first molars (27%), followed by the mandibular first (24%) and second (18%) molars. The failure rates on all other teeth were lower than 10 per cent, with the canines giving the lowest debonding rates (4-6%). An evident individual variation was noted, and a few patients had a high number of failures. Clinical and scanning electron microscopic studies of tooth surfaces following removal of the brackets demonstrated a 'normal' surface appearance when plain-cut tungsten-carbide burs rotated at low speed were used to remove composite material that could not be scraped off, while fine diamonds and even sand paper discs created marked surface scratching.

It is concluded that carefully performed bonding techniques may be of value, particularly on anterior teeth, premolars and mandibular second molars, while the evidence at hand would suggest that first molars are better banded. Also, for retention purposes, direct bonding with composite material opens up a range of new possibilities, which seem to be very promising.

Introduction

In spite of a considerable number of publications on direct bonding over the past 5 years (see Garn, 1976), no post-treatment evaluation following a full period of routine orthodontic treatment has yet been published. Such material now becoming available, the purpose of the present report was to comment upon some of the findings. Although our preliminary experiments have included many bonding techniques and a variety of different bracket types and designs, this report will be largely restricted to experiences with a chemically polymerized diluted composite material (Concise, 3M Company, St. Paul, Minnesota, USA) and metal attachments with perforated backings (GAC International Inc., Farmingdale, New York, USA), which is the bonding combination we have found to be most useful (Zachrisson, 1975; 1976).*

Material and Methods

A total of 612 brackets were directly bonded to different teeth (Table 1) in 75 children aged 11-14 years. All cases were treated with a light wire Edgewise technique where, after initial retraction of the canines by means of sectional arches, the anterior teeth were retracted '*en masse*' by closing loops that were tied back (Figs. 2-4). The orthodontic treatment periods ranged from 9-20 months (mean 17.2 months).

All brackets were bonded and orthodontic treatment performed by the author. The clinical appearance during and after treatment when this bonding method is employed is indicated in Figures 2-5.

Bonding procedure: Enamel surfaces of all teeth to be bonded were cleaned thoroughly with a polishing brush and pumice paste. Following rinsing with water spray, a lip expander, dri-angles and double saliva ejector were placed. Conditioning of 5-10 teeth was performed for about 90 seconds using 37 per cent phosphoric acid applied by 3M pellets no. 1922 or cotton pellets. The etching was extended over the entire tooth surfaces and close to the gingival margins.

After thorough rinsing with water and drying with an air spray until a white frosted appearance was observed, a thin layer of sealant (mixture of the same volume of resins A and B) was painted with 3M pellets over the etched surfaces of 4-6 teeth.

This resin coating is very important, because it (1) confers some degree of resistance to demineralization (Silverstone, 1975; Figs. 2-3), (2) makes removal of the brackets easier, and (3) increases the bond strength (Meurman and Nevaste, 1975).

Some examples of different working times and viscosities in bonding with the Concise system are shown in Table 2. The very short and short working times were useful when brackets were bonded one-by-one. For bonding 3-3 retainers a low-viscous mixture with a long working time was used. (The intermediate working times may be useful whenever several brackets are to be placed in direct or indirect bonding procedures).

For bonding, the diluted composite material was applied directly to the base of the bracket with a toothpick. Various combinations of the four components (two pastes and two resins) were used depending on which consistency and hardening time was desired. The Concise technique is the only bonding method where the working time and viscosity of the material can be easily varied (Table 2), and it allows a shorter working time than any other method, without the use of warm air (Brandt *et al.*, 1975). Therefore, the brackets were generally bonded one at a time, each with a fresh mix. Minute portions of the components in number equalling the number of brackets to be bonded were placed on a large disposable mixing tray, and mixed just before bonding.

Table 1 Failure rates (loose brackets) after full period of orthodontic treatment for GAC metal brackets bonded with Concise

	No. bonded	No. failures	Percentage
Maxilla			
Molars	19	7	27
Premolars	85	11	14
Canines	76	4	5
Incisors	133	9	7
Mandible			
Second molars	34	6	18
First molars	33	8	24
Premolars	9	11	14
Canines	49	2	4
Incisors	104	9	9

Having placed the composite material on the bracket base, the bracket was placed on the tooth surface with forceps; for correct bracket positioning a cement sealer proved to be helpful (Fig. 1A) permitting adjustment of the angulation and height both in the anterior and posterior regions (Fig. 1). Next, the scaler was turned (Fig. 1B), and the bracket was pressed firmly against the tooth surface to secure a thin layer of composite (which in our experience seems to increase bond strength considerably). Using the one-point-contact the bracket was held in place for 5-10 seconds until the material began to set; care was taken not to disturb the material once the hardening process began. Trimming of excess composite was performed with tungsten-carbide burs after the adhesive had set. The archwires were then inserted without delay.

The same procedure was used to re-cement the loosened brackets. Great care was taken to secure optimal oral hygiene, and fluoride supplementation (mouthrinses + toothpaste) was given daily (Zachrisson, 1976).

It is important to stress that slim bracket bases and minute quantities of bonding material were used. Most bases on the market are far too extended, so in this series premolar bases (that were slightly flattened with pliers for contouring purposes) were generally used on the anterior teeth (Fig. 1C, 2, and 3) to improve aesthetics and gingival condition. For the same reason, excess bonding material was avoided. Attempts to cover the bracket bases with

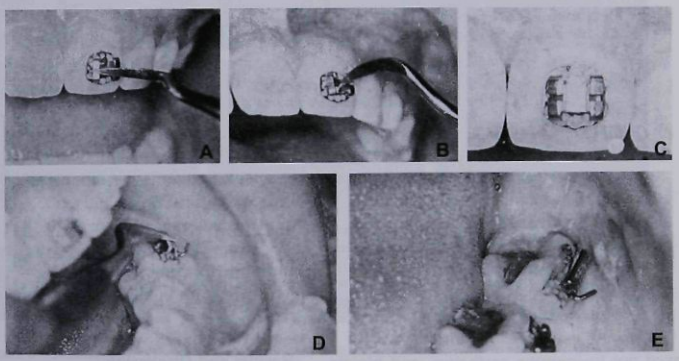

Figure 1 A cement scaler was useful to secure correct bracket placement. A: Adjustment of height and angulation. B: Firm one-point-contact pressure to ascertain thin layer of adhesive and avoid disruption of material during setting process. C: Minute quantities of bonding material and slim bracket bases were used. D: The scaler was particularly useful in the mandibular posterior regions. E: Bonding of partly erupted mandibular second molar.

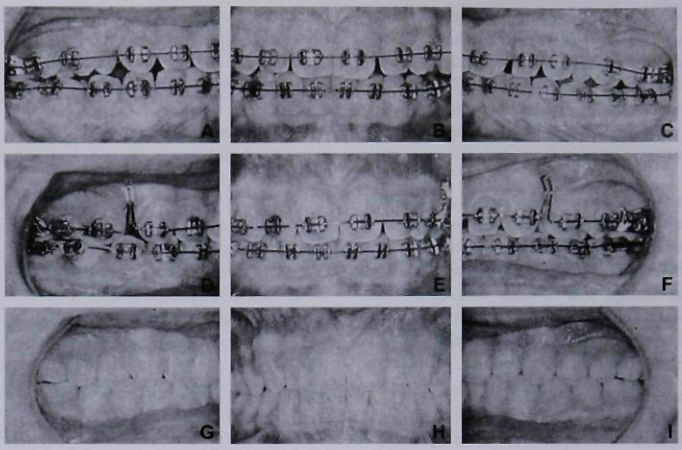

Figure 2 Clinical appearance of a bonded Class II division 1 malocclusion at different stages of treatment. (A-C): During levelling stage with 0.015 inch Twistflex wire. All teeth except the maxillary first molars were bonded with Concise and GAC metal brackets. (D-F): Towards end of treatment. Continuous closing loop archwire (0.017 × 0.022 inch).G-I: Intraoral views after treatment. There is no facial demineralization, and the gingiva is normal.

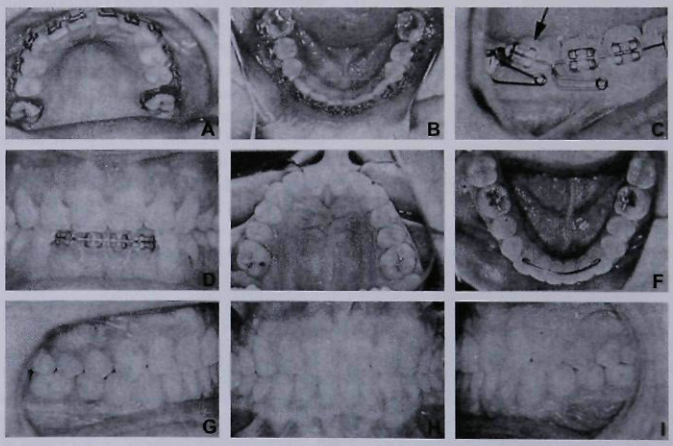

Figure 3 Clinical appearance of a bonded Class II division 2 malocclusion case at different stages of treatment. (A-C): Following 6 months headgear and bite plate therapy, all teeth except the first molars were bonded with Orobond adhesive. However, during the levelling stage several of these brackets came off (arrows). All brackets were replaced by GAC metal brackets bonded with Concise. (D): Towards end of treatment. Mandibular anterior region still bonded. (E-F): Occlusal views after treatment. (G-I): Intraoral views after treatment. Excellent gingival condition and no caries.

composite proved not to improve aesthetics, and plaque was readily attracted to these attachments. Moreover, the brackets were much easier to remove when so little material was used that the plier could be adapted directly under the base (Fig. 6A).

Results and Discussion

Failure rates

The overall failure rate in terms of loose brackets was 11 per cent, but, of course, the debonding varied according to

the different teeth (Table 1). The maxillary first molars showed the highest debonding rates (27%), whereas more than 90 per cent of the incisor and canine brackets stayed on throughout treatment. Brackets bonded to premolars did not attach quite as well. In the mandible, all six anterior teeth had failure rates below 10 per cent, while the premolars and, particularly, the molars showed higher rates. A marked individual variation was noted. Some patients lost several brackets and, when rebonded, such brackets had a tendency to come loose again.

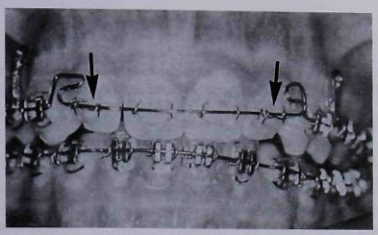

Figure 4 Clinical appearance of plastic-bonded maxillary anterior teeth after 16 months of treatment. Note that wide single GAC plastic brackets on lateral incisors have broken wings (arrows).

It should be remembered that the figures in Table 1 include all the early failures, for example due to inexperience and to too heavy a pull during ligation. It soon became clear that it was necessary to modify the ligation technique when any bonding technique was used, since heavy pull was not tolerated. When active ligations were performed, the archwire should therefore be pressed into the bracket with a finger or instrument instead of pulling it tight with the ligature wire.

The above debonding rates should be compared with figures for loosened bands. Such data are scarce but a recent study claimed that the frequency of loose bands may amount to some 10 per cent per year (Wisth and Bergencreutz, 1975). This would imply that the failure rate for bonded brackets in the anterior region is low.

The clinical implication of these data would be that direct bonding is here to stay. At least the six anterior teeth in both dental arches and the mandibular second molars may be bonded as a routine. Admittedly the mandibular second

Figure 5 Gingival condition in the premolar region at start (A) and end (B-C) of orthodontic treatment in a patient with excellent oral hygiene. The gingiva is perfectly healthy with evident stippling (arrows).

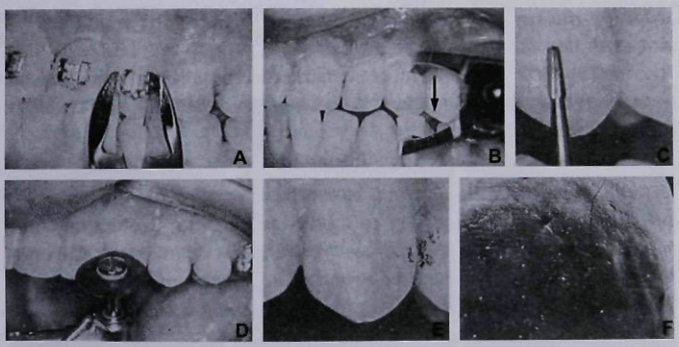

Figure 6 Technique for removal of brackets bonded with composite material. (A): an ETM plier no. 1026 placed over the mesial and distal part of the bracket to be loosened by slow pressure. (B): Remaining composite is removed with ETM plier no. 349. (C): Pieces that cannot be scrapped away are removed with a tapering tungsten-carbide fissure bur (Jet but no. 1171). This bur removes the composite material quickly and is gentler to the enamel than diamonds, sand-paper discs, alpine stones, etc. To increase contrast against enamel, water-cooling is not used when removing the last remaining adhesive. (D): Polishing with AABA polishing disc. (E-F): Clinical and scanning electron microscopic appearance following this procedure.

molars had rather high failure rates, but these teeth are also difficult to band, particularly when only partly erupted (Fig. 1D-E). First molars, on the other hand, should preferably be banded (cf. Garn, 1976), because (1) the stronger attachment is advantageous whenever headgear and lip bumpers are used, (2) lingual attachments (for elastics, palatal bars, lingual arches etc.) are frequently used, and (3) interproximal caries protection is inherent (see below). The premolars are in an intermediate position. These teeth appear best suited for bonding when fully erupted and for treatment of a short duration.

Plastic brackets

Whenever polycarbonate brackets are used with a composite material (Nuva-Tach and Concise) a methyl methacrylate primer must be used to pre-treat the bases. In agreement with others (Garn, 1976) we have been successful in terms of bond strength (Table 3), but the main problem with the present plastic brackets was that the wings broke too frequently towards the end of treatment. Even the new solid GAC plastic brackets showed frequent wing breakage having been exposed to the oral milieu for a year or more (Table 3, Fig. 4).

To try to overcome this problem, a few cases were bonded with tooth coloured metal brackets on mesh pads (Dentaurum, Pforzheim, West Germany) on the upper anterior teeth, and GAC brackets on the remaining teeth. However, the colour gradually wore off within months, and we do not use these brackets any more.

Table 2 Some examples of different working times and viscosities in bonding with the Concise system. The very short and short working times were useful when brackets were bonded one-by-one. For bonding 3-3 retainers a low-viscous mixture with a long working time was used. (The intermediate working times may be useful whenever several brackets are to be placed in direct or indirect bonding procedures)

Working time	Mixture	Viscosity
Very short	Paste A + Resin B (2:1)	Thick
Short	Paste A + Resin B (1:1)	Semi-fluid
Medium	Paste A/Resin A + Paste B	Semi-fluid
Long	Paste A/Resin A + Paste B/Resin B	Thin
Very long	Resin A + Paste B (1:1)	Semi-fluid

Gingival condition

One of the claimed advantages of direct bonding is improved gingival condition. However, this was not necessarily true. When bracket bases were overextended or much bonding material was used, the gingiva could be worse than when bands were used (Zachrisson, 1976). On the other hand, when bases were slim, little bonding material was used and oral hygiene was good, the gingiva could be maintained in a normal condition. Figure 5 shows the lower right segment in such a patient at the start and towards the end of treatment 18 months later. The gingiva was kept in perfect health with evident stippling throughout treatment. Such excellent gingival conditions was never experienced in banded patients (Zachrisson and Zachrisson, 1972).

Dental caries

Dental caries may occur along bands when oral hygiene is poor, and under loose bands. In direct bonding such demineralization may be eliminated on facial and lingual surfaces provided fluoride is given regularly and oral hygiene is good (Zachrisson, 1976) and a resin sealing is made (Figs. 2-3). However, interproximal caries may still be a problem. Caries may progress under bands, but the rate

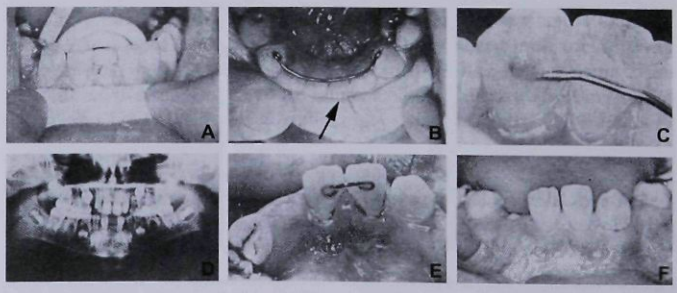

Figure 7 Bonding for retention purposes. (A-C): 3-3 retainer made of 0.9 mm blue Elgiloy wire. A thin steel ligature (arrow) gives excellent fixation so that the adhesive material may set undisturbed. (D-F): Mandibular lateral incisors bonded by with means of a thin square wire to allow mesial eruption of canines in case with multiple agenesia. (D: at start, E-F: after orthodontic positioning of lateral incisors mesially). A second phase of treatment will be needed lateral.

Table 3 Bonding of a limited number of GAC new plastic brackets with Concise (after pre-treatment of bases with primer) was successful in terms of bond strength, but indicated too man broken wings towards the end of the orthodontic treatment period.

Teeth	(3) 21 + 12 (3)
Observation period	Since September 1975
Number of loose brackets	4 (8%)
Number of broken wings	16 (34%)

of progression is retarded (Quinn, 1956), while in bonding no such protection is present.

Our findings demonstrated that the number of new interproximal caries lesions was very small, but it was important to check this regularly during treatment, particularly with regard to secondary caries and previously undetected lesions, since some lesions had to be treated at various stages of the orthodontic treatment period.

Removal

Removal of bonding material after the orthodontic treatment was initially a problem, and, for that reason, a technique based on clinical experiences and scanning electron microscopic studies was developed (Fig. 6). The instruments used were pliers 1026 and 349 (ETM, Monrovia, California, USA) and a plain-cut tungsten-carbide bur (JET bur no. 1171, Beavers Dental Products Ltd., Morrisburg, Ontario, Canada) rotated at low speed (Hannah and Smith, 1973). As shown in Figure 6A the brackets were removed with the 1026 plier and the 349 plier was used to scrape away remaining material (Fig. 6B). A cement sealer could also be used but it was not so efficient. Bonding material that could not be scraped off was taken away with the tungsten-carbide bur (Fig. 6C). Next, the surface was polished with an AABA polishing disc (Fig. 6D) [Idento-flex A.G., Buchs/SG, Switzerland]. This procedure constantly produced nice, clean surfaces, as demonstrated clinically (Fig. 6E) and in the scanning electron microscope (Fig. 6F).

The use of diamond instruments is not advised (Hannah and Smith, 1973; Zachrisson, 1976), since even at a clinical level they left extensive scratches. In the scanning electron microscope the difference between a fine diamond and a plain-cut tungsten-carbide bur was enormous, and it could be seen that even fine sand paper discs created considerable surface scratching. If the orthodontist leaves such scratches in the facial enamel surfaces of several teeth the risk of late discolouration is increased. Sine the technique described was used, no discolouration has been observed in any of the patients for periods of up to 1 year following removal of the brackets.

Retention

Bonded 3-3 retainers have several advantages, in that they are completely invisible and can be left in place for long periods without risk of demineralization (Wolfson and Servoss, 1974; Zachrisson, 1976). Out of 34 such retainers bonded with Concise over the last $1\frac{1}{2}$ years, breakage has occurred in two cases only. When making the retainers the lingual bar may be attached to the teeth with a thin steel ligature (Fig. 7A, B) after etching. This gave a good hold, so that a thin mix of composite (cf. Table 2) could be used allowing for a smooth surface (Fig. 7C).

A number of other retention methods have been tried. For example, in the case shown in Figure 7D-F, where the mandibular central incisors were congenitally missing, a lingual wire was bonded to the lateral incisors after having moved them mesially, thus allowing the canines to erupt in mesial positions. In other cases, particularly in closed median diastemas a similar approach has been used with Twistflex wire, while splinting contact points with different adhesive materials without wire reinforcement was not too successful, as reported previously (Zachrisson, 1975).

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***Addendum**

Development in the field of bonding is rapid. More recent data than presented here indicates that the failure rates can be further considerably reduced with improved techniques. Although the principles for bonding as outlined in this article are still the same, our present approach for routine bonding (June, 1977) includes the use of mesh-backed rather than perforated brackets; a new adhesive with smaller filler particles, increased stickiness and a longer working time permitting the removal of excess adhesive before setting (Endur, Ormco Corp.); improved lip expanders not restricting the working field and probanthine injections for salivary control almost eliminating the need for dri-angles and salivary ejections. Because of its quick setting and resistance to abrasion, Concise adhesive is still preferred for rebonding of loosened brackets and for retainers.