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Clinical comparison of an adhesive precoated vs. an uncoated ceramic bracket system

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Structured Abstract
Authors – Verstrynge A, Ghesquiere A, Willems G.
Objectives – To clinically evaluate the bond characteristics of the adhesive precoated ceramic (APC) Clarity bracket and compare it with the uncoated Clarity bracket used with Transbond XT bonding system.
Design – A randomized clinical trial.
Settings and Sample Population – Department of Orthodontics, Katholieke Universiteit Leuven. Twenty patients requiring bonded fixed orthodontic appliance from central incisor to second bicuspid.
Experimental Variable – APC Clarity brackets were bonded in the first and fourth quadrant of group 1 and in the second and third quadrant of group 2. Uncoated Clarity brackets were bonded with Transbond XT in the second and third quadrant of group 1 and in the first and fourth quadrant of group 2.
Outcome Measure – During orthodontic treatment, bracket failures were registered. At debonding, the tooth surfaces were intraorally scored according to the Adhesive Remnant Index.
Results – During treatment one tie wing fractured in the APC group and no bond failures occurred. At debonding, no significant differences between the APC and Transbond XT could be shown in any of the quadrants.
Conclusion – The two groups performed identically.

Key words: adhesive precoated ceramic; Adhesive Remnant Index; bond characteristics; uncoated ceramic bracket

Introduction

In today's society more adults seek orthodontic treatment (1). But because the appearance of orthodontic appliances is important to the adult patient, more esthetic alternatives to the stainless steel bracket have been introduced (2, 3). Bandless appliances following the advent of the acid etching technique was readily accepted (4–6). In the early 1970s, polycarbonate plastic brackets were introduced, but were soon found to be unstable in the oral cavity, showing distortion and inadequate arch wire/slot control (7–9). The more advanced techniques of reinforcing the polycarbonate with ceramic fillers or incorporating a metallic slot into the plastic bracket (2, 3, 10), could not provide total integrity over long term treatments either (11). Even the development of lingual appliances, so called 'invisible orthodontics' (12), has only limited applications. They are technically difficult and extremely time consuming to fit and adjust (3). The search for the ultimate esthetic bracket introduced ceramics (3). Ceramic brackets, which came into use in the late 1980s, overcame some of the limitations of plastic brackets. Their appearance is very good, chemical resistance is excellent and they are both hard and strong, but they too possess certain shortcomings (2, 11).

For a fixed appliance to be successful it must have adequate bond strength. The overall time required to place an appliance is an important factor in the cost of treatment, whilst the need to replace brackets frequently may severely impair the progress of fixed appliance treatment and can be costly in terms of materials and time (13). With metal brackets, the critical question for the clinician was whether the bond was too weak to withstand the forces applied during orthodontic treatment. With ceramic brackets, clinicians became concerned about whether the bond was too strong for safe debonding (14). Ceramic brackets are more rigid and do not flex or bend as do metal brackets. This low fracture toughness can be explained by the specific atomic structure of ceramics (Al_2O_3), which does not permit shifting of atomic bonds and redistribution of stresses (15). During debonding, the ceramic brackets do not bend, to break up the adhesive force of the composite or the cohesive force between the bracket and adhesive system. Debonding forces fracture the ceramic bracket or break the adhesive system at the tooth/composite surface, which often creates cracks in the susceptible enamel.

Factors that influence the bond strength are the bracket base design (retention mechanism), composition of the adhesive used for bonding, and the conditioning of the enamel. Bracket base design may allow for macro-mechanical (16–18), micro-mechanical (18, 19) or chemical bonding (10, 17, 18, 20–23) between the bracket base and the composite. Also the filler content of a specific adhesive may influence its physical performance. A high filler content may result in less cohesiveness and more adhesive failures (24, 25). Finally, it is well known that both adequate cleaning of the enamel surfaces and the method of enamel conditioning are equally important in the process of obtaining an adequate bond strength.

Adhesive precoated ceramic (APC) brackets have been introduced recently. Cooper et al. (26) described the following advantages: consistent quality and quantity of adhesive, easier clean-up following bonding, reduced waste during bonding, improved asepsis and better inventory control. All are rather obvious but the question still remains whether clinically the APC systems perform adequately.

The aim of this study was to evaluate the clinical performance, relating the bond characteristics, of the adhesive precoated (APC) Clarity (3M Unitek) bracket and compare it with the uncoated Clarity bracket, applying Transbond XT (3M Unitek) as the bonding system.

Materials and methods

This study employed only the Clarity bracket (3M Unitek Dental Products, Monrovia, CA, USA), which is available in standard uncoated and adhesive precoated (APC) versions. The Clarity bracket has micro-mechanical retention incorporated into the base and has a metal-lined arch wire slot. The adhesive system used for the uncoated version was the Transbond XT (3M Unitek Dental Products) light cured adhesive (3M Unitek), while a modified version of Transbond XT was precoated onto the bases of the APC brackets by the manufacturer.

Using a generated list, 20 patients were randomly selected into two groups (Table 1).

All bonded teeth from central incisor to second bicuspid were prepared carefully, as described by the manufacturer's instructions. First and second molars in upper and lower jaw were either banded or bonded with a standard edgewise-metal molar bracket or tube. While orthodontic treatment was carried out,

Table 1. **Twenty patients are randomly selected into two groups, creating two subgroups: Adhesive Remnant Index-right (ARI-R) and ARI-left (ARI-L)**

	Right upper and lower quadrant (subgroup ARI-R)	Left upper and lower quadrant (subgroup ARI-L)
Group 1	APC	Transbond XT
Group 2	Transbond XT	APC

APC, adhesive precoated ceramic.

bracket failure of any kind was marked in the patient file.

At debonding, all tooth surfaces were intra-orally scored according to the Adhesive Remnant Index (ARI). This index, described by Årtun and Bergland (27) in 1984, has four grades, ranging from 0 to 3 (0, no adhesive left on tooth; 1, less than half of the adhesive left on tooth; 2, more than half of the adhesive left on tooth; 3, all adhesive left on tooth with distinct impression of the bracket base). All debonded brackets were examined under a stereomicroscope at ×50 magnification to confirm the amount of adhesive remaining on the enamel surface. This leads to the creation of two subgroups ARI-left (ARI-L) and ARI-right (ARI-R), being all ARI scores evaluated and grouped according respectively to the left and right side of the patient (Table 1).

The non-parametric Mann–Whitney *U*-test was used to determine whether significant differences existed between the APC Clarity bracket and the uncoated Transbond XT Clarity bracket on the right side of all patients, relating to the variable ARI (i.e. ARI-R). The same statistical testing was done for all ARI scores on the left side of all patients (i.e. ARI-L). The non-parametric Wilcoxon test (pared data) was used to determine whether significant differences existed between the overall APC and Transbond XT group, with no regard to the left or right side of the patients. The significance for all the statistical tests was corrected for multiple testing (Bonferroni correction) and was predetermined at $p < 0.01$.

Results

During treatment, only one tie wing fracture was found in the APC group, probably induced by tieing a metal ligature too strongly. Bond failures during treatment were not encountered in any of the groups. At debonding no enamel surface damage was found macroscopically. Descriptive statistics shows the histograms of the two discrete variables ARI-R (Fig. 1) and ARI-L for both bracket systems (Fig. 2) after debonding. The non-parametric Mann–Whitney *U*-test shows no significant difference between the ARI scores of APC and Transbond XT for the two variables ARI-R and ARI-L ($p > 0.01$). Also the results of the APC group and the Transbond XT group, being respectively, all the APC brackets and uncoated Transbond XT brackets on the right or left side of all patients, are described in the same manner (Fig. 3). The non-parametric Wilcoxon test (pared data) showed no significant difference between both the APC and the Transbond XT group ($p = 0.55$).

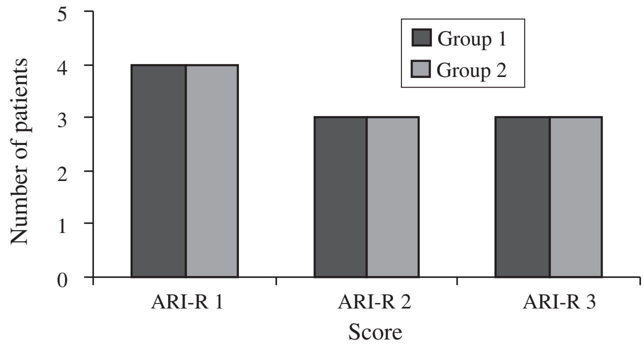

Fig. 1. Histogram indicating Adhesive Remnant Index scores in the right upper and lower quadrant for both groups of patients, being adhesive precoated ceramic for group 1 and Transbond XT for group 2.

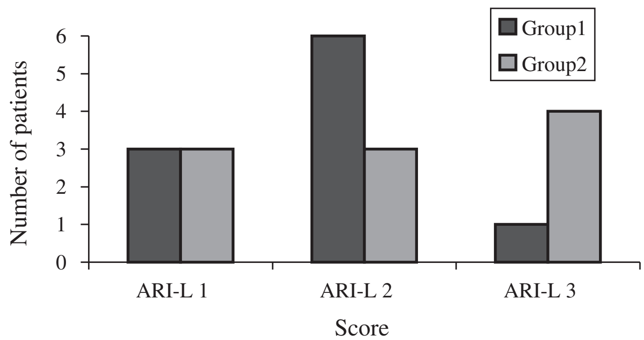

Fig. 2. Histogram indicating Adhesive Remnant Index scores in the left upper and lower quadrant for both groups of patients, being Transbond XT for group 1 and adhesive precoated ceramic for group 2.

Discussion

The new metal reinforced ceramic Clarity bracket was introduced with the intention of decreasing the enamel

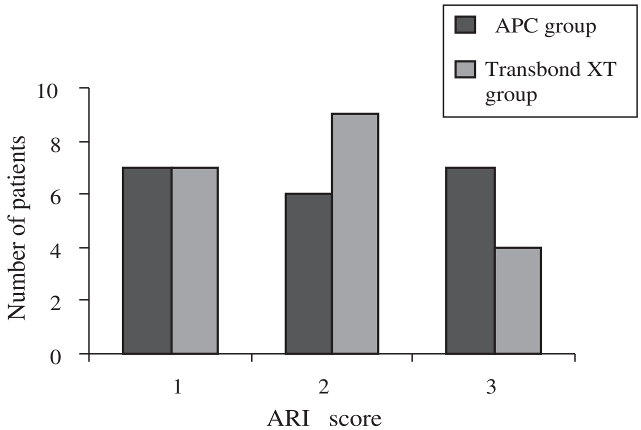

Fig. 3. Histogram indicating Adhesive Remnant Index scores using adhesive precoated ceramic or Transbond XT for both groups of patients.

damage during debonding. In the current study, an attempt was made to determine whether precoating ceramic brackets affects the bracket base–adhesive interface or the adhesive–enamel interface. By looking at the ARI scores (Fig. 3), the findings indicate that there is no difference between the amount of adhesive remnants left on the enamel surfaces using the APC Clarity brackets or the uncoated Clarity brackets as far as the debonded tooth surfaces are of concern.

The Clarity bracket has micro-mechanical retention incorporated into the base. Mundstock et al. (28) described small, but significant, differences in the ARI scores between conventional ceramic brackets (Transcend 6000; 3M Unitek Dental Products) and Clarity brackets (uncoated version). The Clarity brackets showed a tendency to have all the composite remaining on the tooth when the brackets were removed. The results of the study of Bishara et al. (29) indicate that the site of bond failure during debonding varies significantly according to the technique of bracket removal. To reduce the clinical incidence rate of irreversible enamel surface damage, three methods of debonding ceramic brackets have been suggested. These methods include: (1) the conventional methods that use pliers or wrenches, (2) the electrothermal method that involves an apparatus that transmits heat to the adhesive through the bracket, and (3) an ultrasonic method that uses special tips (30, 31).

Debonding of the Clarity brackets is done in a novel way. Both mesial and distal wings of the bracket slot are squeezed towards each other. This causes vertical breakage of the Clarity bracket base according to a vertical line that is scored in the manufacturing process in order to reduce the resistance of the bracket base against this type of vertical fracture. This can be seen as a built-in protection mechanism against enamel damage at debonding. As a possible disadvantage one can argue that this seems to leave more composite on the tooth surface compared with other systems. Sometimes, this debonding method imposes the risk of bracket fracture. In this case, the removal of remaining fragments of the ceramic brackets from the enamel surface has to be carried out with a high-speed diamond bur. This procedure is time-consuming, produces large fragments of the bracket during grinding, and results in large amounts of ceramic dust which has been associated with itchy skin on hands and eye irritation (23). Grinding ceramic material from the tooth surface may generate heat, which can damage the dental pulp, if low-speed grinding without coolant is used (32).

The two adhesives used on the precoated and the uncoated brackets, incorporate the same ingredients but in the precoated adhesive, one of the changes included an increase in the amount of filler (80 vol%) when compared with the amount present in the Transbond XT adhesive used with the uncoated brackets (77 vol%) (33). The purpose of adding more filler to the adhesive on the precoated bracket is to increase its viscosity in an effort to allow the composite to remain on the bracket base and not flow off. Bishara et al. (33) found that the increased viscosity of the adhesive used on a coated metal bracket, when combined with the mesh retention mechanism incorporated in the metal bracket base, seemed to increase the frequency of an ARI score of 3, i.e. all the adhesive remaining on the enamel surface, suggesting a relatively weaker bond between the adhesive and the mesh (33). This could not be confirmed in our study.

A number of other factors contribute to bond strength between the ceramic bracket and the enamel, including the length of etching time, the acid concentration, the type of acid solution and enamel condition. Olsen et al. (34) found no significant differences between the ARI of the teeth etched for 30, 20, 15 and 10 s with 37% phosphoric acid. In a study of Sadowsky et al. (35) during treatment with ceramic brackets, there were as much bond failures in the 15-s etch group (37% phosphoric acid) as in the 60-s etch group, but there were twice as many failures in the

15% phosphoric acid group (60 s) than in the 37% phosphoric acid group. Maskeroni et al. (36) compared the bond strength of ceramic brackets with polyacrylic acid and phosphoric acid conditioning. With the phosphoric etching technique, the majority of acrylic resin remained on the enamel surface after debonding. The polyacrylic acid crystal growth technique (etching with polyacrylic acid solution for 30 s and gently washed with water without air pressure) resulted in bond fractures at the enamel/resin interface, with the majority of acrylic resin remaining on the bracket pad.

Scott (37) has pointed out that the tensile strength of ceramics is dependent on the surface conditions of the ceramic. The tensile strength of metals is a bulk material property with little or no regard for the surface conditions. The tensile strength of ceramics is not a simple bulk material property. It is particularly dependent on the condition of the surface of the ceramic. A shallow scratch on the surface of the ceramic will drastically reduce the load required for fracture whereas, the same scratch on a metal surface will have little or no effect on fracture under load (37). Viazis et al. (38) used SEM and fractographic analysis for the evaluation of clinical failures of single crystal ceramic brackets (first generation – Starfire). They determined that the majority of failures originate in either the arch wire slot or the tie wing slot. The fractographic analysis was helpful in determining that the primary causes of failure are internal defects and machining interferences. Improvements in the manufacturing techniques and design resulted in the improved version of monocrystalline (second generation) brackets with less cohesive bracket failures than reported (39). The problem of bracket failure may also occur when placing or removing rectangular archwires that almost completely fill the slot. The risk of this can be reduced by using a more resilient full size wire before placing the stainless steel finishing arch wire. Placement of additional torque in arch wires may cause tie wing fracture on insertion with ceramic brackets and consideration should be given to increasing the amount of torque by inverting the bracket or even by using a torquing auxiliary rather than by incorporating torque in the arch wire (11). The one tie wing fracture we experienced was probably because of tieing a metal ligature around the Clarity tie wings much too strongly.

Conclusion

We could not demonstrate any clinically significant differences between the APC bracket and the uncoated XT ceramic bracket system that were related to the bond characteristics of the ceramic bracket to the tooth surface.

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