Clarity™ ADVANCED Ceramic Brackets A Technical Perspective

by Nicole Wagner, Bill Wyllie, and Glenys Thorstenson

Nicole Wagner is a Senior Technical Service Engineer at 3M Unitek. She received her B.S. in Chemistry from the State University of New York at Stony Brook. Her M.S. and Ph.D. are in Mechanical Engineering from the University of Minnesota, where her research focused on synthesis, characterization, and reaction modeling of hard, wear-resistant ceramic materials. She has been at 3M since 2007, joining 3M Unitek in 2010.

Bill Wyllie is a Product Development Specialist at 3M Unitek. He is active in the development of new aesthetic materials for brackets, and has worked on a variety of product development teams such as SmartClip™ and Clarity™ SL Self-Ligating Brackets and Forsus™ Class II Correctors. He received his B.S. in Materials and Metallurgical Engineering from the University of Michigan and his M.S. and Ph.D. in Materials Engineering from Rensselaer Polytechnic Institute. He has been at 3M Unitek since 1997.

Glenys Thorstenson received her B.S. in Materials Science and Engineering from Michigan State University and her Ph.D. in Biomedical Engineering from the University of North Carolina at Chapel Hill. Her dissertation focused on the resistance to sliding of novel orthodontic bracket systems. She has been at 3M Unitek since 2003.

Introduction

As more patients seek a more aesthetic orthodontic treatment, orthodontists still demand functionality in their orthodontic appliances. Through various discussions with orthodontists and assistants, the 3M Unitek product development team assessed that ceramic brackets need to maintain the characteristics of aesthetics, small physical size, strength, predictable debonding, and a design that is comfortable to patients. New Clarity™ ADVANCED Ceramic Brackets incorporate these features into a revolutionary design to give orthodontists the aesthetics and efficiency they require.

Bracket Material and Design

Advances in materials, manufacturing technologies, and bracket design have enabled new levels of performance in the Clarity™ brand of aesthetic brackets. Clarity™ ADVANCED Ceramic Brackets are made of polycrystalline alumina, which consists of small crystals, called “grains” (Figure 1A-B). As the size of these grains decreases, the strength of the ceramic material increases (Figure 2). Clarity™ ADVANCED Brackets are made of the same material

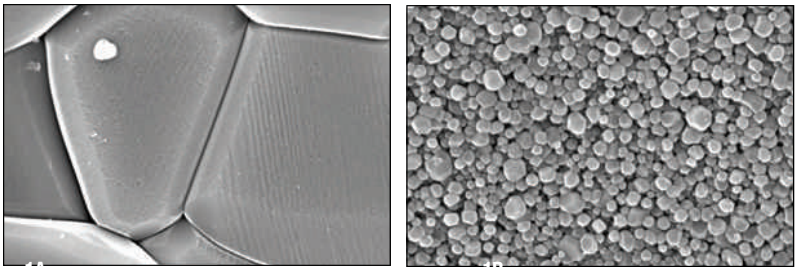

Figure 1A-B Average alumina grain size of (A) 15 µm (Clarity™ Metal-Reinforced Ceramic Bracket) and (B) 0.9 µm (Clarity™ ADVANCED Ceramic Bracket).

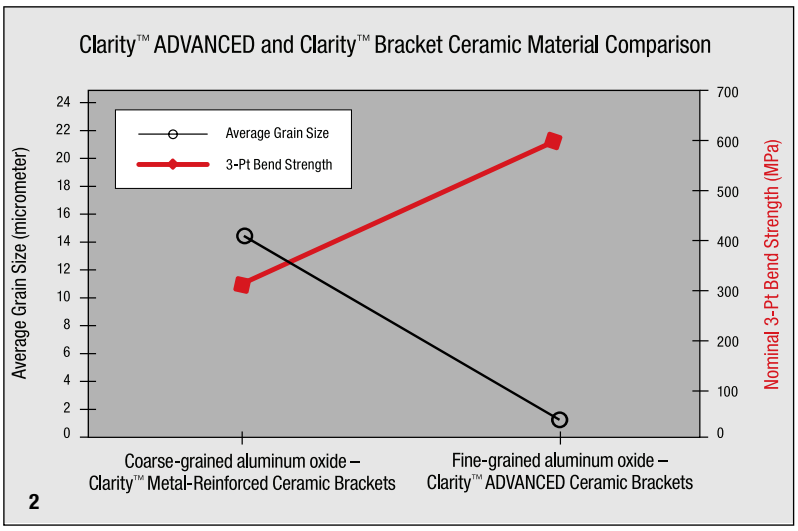

Figure 2 As average grain size decreases, strength of material increases.

as that used in Clarity™ SL Self-Ligating Brackets, which is a finer-grained ceramic than the leading polycrystalline ceramic brackets. In addition, the finer grain size of the ceramic material in Clarity™ ADVANCED Ceramic Brackets improves its inherent material strength as compared to the material used in Clarity™ brackets. Therefore, as seen in tie-wing crush strength testing, while overall smaller in size, the strength of the Clarity™ ADVANCED brackets is comparable to Clarity™ brackets. Also, since the material is the same as that used in Clarity SL brackets, the material is proven to resist staining to various staining agents throughout the course of treatment. In addition, the translucent material of the Clarity™ ADVANCED brackets blends with the color of various tooth shades.

Clarity™ ADVANCED brackets are fabricated by an injection-molding process. This method permits the creation of smooth, rounded corners designed to reduce binding and notching at the bracket slot corners. Binding is an element of friction that contributes to the resistance to sliding when the archwire is in contact with the corners of the bracket slot. It is impacted by the materials and geometries of the archwires and brackets, and does not depend on the force applied by the ligature[1].

Another factor that contributes to friction is notching, which is the resistance to sliding when the bracket permanently deforms the archwire. Most often, notching is due to the ligature force and occurs on the lingual side of the archwire. However, notching can also occur on the occlusal or gingival sides[2]. Images of bracket slot corners of Clarity™ ADVANCED brackets and other ceramic brackets that are currently on the market are shown in Figure 3A-D. The bracket slot corners of the Clarity™ ADVANCED brackets appear to be more rounded and smooth compared to the other ceramic brackets.

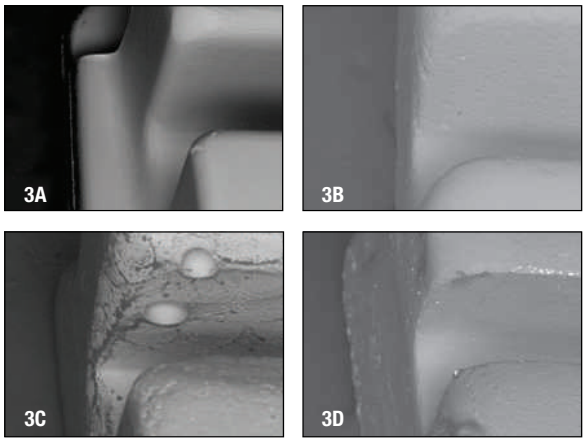

Figure 3A-D Bracket slot corners of (A) 3M Unitek Clarity™ ADVANCED, (B) American Radiance™, (C) GAC Mystique™, and (D) Ormco Inspire ICE™ Brackets.

To allow for an increased inter-bracket distance, Clarity™ ADVANCED brackets are designed to have small mesio-distal dimensions. For reduced occlusal interference, Clarity™ ADVANCED brackets have small occlusal-gingival dimensions. In addition, Clarity™ ADVANCED brackets feature a generous under-tie-wing area to allow for both single- and double-ligation. Of the doctors surveyed during a ligation study (3M Unitek), 91% found that the Clarity™ ADVANCED brackets easily accommodate double-ligation.

Bonding Base and Predictable Debonding

The bonding base of Clarity™ ADVANCED brackets has been designed with a tooth-specific anatomy, similar to Clarity and Clarity™ SL brackets, to contour to the shape of patients' teeth and provide a better fit to each tooth. Also, similar to Clarity and Clarity™ SL brackets, Clarity™ ADVANCED brackets have a micro-crystalline surface on the base to create a mechanical bond with the adhesive (Figure 4).

Figure 4
Clarity™ ADVANCED Ceramic Bracket bonding base with stress-concentrator.

To maintain the predictable debonding that orthodontists are accustomed to with the Clarity™ brand of brackets, the new Clarity™ ADVANCED ceramic brackets also feature the proprietary stress-concentrator vertically along their bracket base (Figure 4). When debonding a bracket, the adhesive first breaks at the edge of the bracket, initiating a crack that continues through the adhesive layer along the bracket base, after which the stress-concentrator collapses the bracket vertically in half[3]. With a mesial-distal 'rocking' motion, first towards the half of the bracket where the adhesive first broke, then towards the other half, the Clarity™ ADVANCED bracket can be removed entirely from the tooth. The recommended debonding tool is the same as that used for Clarity™ SL brackets, namely the Unitek™ Self-Ligating Bracket Debonding Instrument. To remove a bracket, this instrument is inserted in the labial side of the bracket with the instrument blade along the vertical

center slot and its ledges seated on the tie-wings. Using the mesial-distal squeeze debonding technique, Clarity™ ADVANCED Ceramic Brackets can be debonded on or off the archwire (Figure 5A-B). When debonding on the archwire, the ligature supports the collapsed bracket halves. Care should be taken to grasp and hold the collapsed bracket when debonding off the archwire.

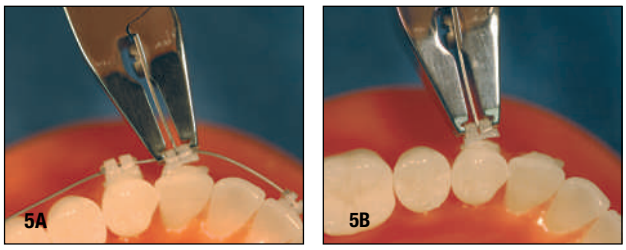

Figure 5A-B Debonding Clarity™ ADVANCED Ceramic Brackets using the Unitek™ Self-Ligating Bracket Debonding Instrument either (A) on or (B) off the archwire.

Patient Comfort

Clarity™ ADVANCED brackets are designed to provide enhanced patient comfort. By using an injection-molding process, smooth, rounded corners are created. The dome-shaped design and rounded bi-directional ball hooks are intended to further improve patient comfort.

The low profile design of Clarity™ ADVANCED brackets aims to provide patients with enhanced comfort. In addition, the low profile of lower anterior Clarity ADVANCED brackets reduces occlusal interference, giving orthodontists more flexibility to use ceramic brackets on a patient's lower arch. Clarity™ ADVANCED brackets have an in/out dimension that is compatible with that of Victory Series™ Low Profile Brackets.

Conclusions

Clarity™ ADVANCED brackets are a new generation of ceramic brackets with both aesthetics and functionality. The aesthetics of the bracket are enabled by its translucent fine-grained alumina material and low-profile design. The smooth, rounded features of the bracket can both reduce binding and notching during treatment and assist with increasing patient comfort. With these features and the predictable debonding that remains a key feature of the Clarity™ brand, the Clarity™ ADVANCED bracket system provides an excellent aesthetic solution for both patients and orthodontists.

References

1. Thorstenson GA, Kusy RP, "Effect of archwire size and material on the resistance to sliding of self-ligating brackets with second-order angulation in the dry state" Am J Orthod Dentofacial Orthop 2002; 122: 295-305.
2. Articolo LC, Kusy K, Saunders CR, Kusy RP, "Influence of ceramic and stainless steel brackets on the notching of archwires during clinical treatment" Eur J Orthod 2000; 22: 409-425.
3. Hansen J. "Ceramic Orthodontic Bracket with Debonding Channel" US Patent Number 5439379, 8 Aug 1995.