DESIGN AND DEVELOPMENT OF THE ULTIMATE CERAMIC BRACKET

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Abstract: Ceramic brackets have gained widespread acceptance in orthodontic treatment due to their superior aesthetic appeal. The immediate popularity of these brackets, after their initial marketing, was tempered by their potential to damage the enamel during debonding. This paper describes the design and development of a ceramic bracket that addresses the failings of most ceramic brackets on the market today. The advancements in the design, ability to debond easily and superior bond strength make this injection-molded, low-friction bracket a truly unique choice in the field of aesthetic brackets. This white paper compares the characteristics of this bracket with other leading ceramic brackets on the market.

Introduction

The popularity of ceramic brackets is well documented by their rapid acceptance as aesthetic brackets of choice. While the sales of ceramic brackets are on the rise in recent years, plastic brackets have shown a marked decline. After a euphoric initial product launch, sales of ceramic brackets were almost shut down, due to catastrophic delamination of enamel during debonding. The overall sentiment in the orthodontic community was summarized by Dr. Mike Swartz as "Never before in orthodontics has so much intentional damage to enamel occurred."[1] Bishara[2] writes about the necessary precautions when debonding some brackets that have to be shattered in the mouth. He also writes about the greater susceptibility to cracking with machined ceramic brackets that have micro-cracks on the surface.

In the mid 1990's two orthodontic companies relaunched ceramic brackets with engineered bases to assure safe debonds. One was the MXi® bracket from TP Orthodontics and the other was Clarity, from Unitek. Ceramic brackets in the market today are listed in Table I.

TABLE I. Ceramic Brackets

Bracket Name	Manufacturer
MXi	TP Orthodontics
InVu	TP Orthodontics
Clarity	Unitek
Signature III	RMO
Luxi II	RMO
Virage	American Orthodontics
Mystique	GAC
Inspire	Ormco

The MXi bracket incorporates an integral polymer mesh base, which guarantees excellent bonding and also safe debonding. While the MXi brackets have demonstrated superior clinical performance, a new series of ceramic brackets called InVu™ has been introduced with significant improvements in product design, low friction, bonding and also reliable and safe debonding characteristics.

Design Rationale

The InVu ceramic bracket has been designed to optimize various key design parameters, such as:

- Profile height (offers the lowest).
- Low friction (comparable to metal brackets).
- Ease of debonding (debonds just like metal brackets).
- Good bond strength (only ceramic bracket offering a mesh base).
- Smooth radii on all edges to prevent archwire binding and cutting of elastomerics.

True Twin Bracket Design

InVu incorporates a true twin bracket design (Figure 1). It

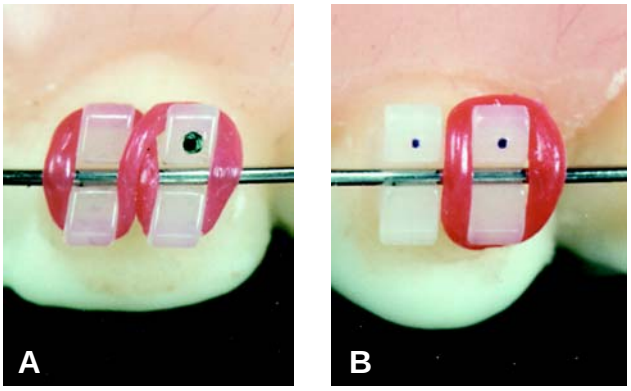

Figure 1. InVu – Twin bracket design

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has four individual tie wings to allow for various modes of ligation, i.e. figure 8's, diagonal, single wing ties, etc. The tie wings provide substantial overhang for reliable ligation (Figure 1a).

The mesiodistal aspect (arch wire slot length) is wide enough to permit excellent tip translation and rotational control. The inter-tie wing space is large enough to allow for bracket position alignment using a flat bladed adjuster (Figure 2).

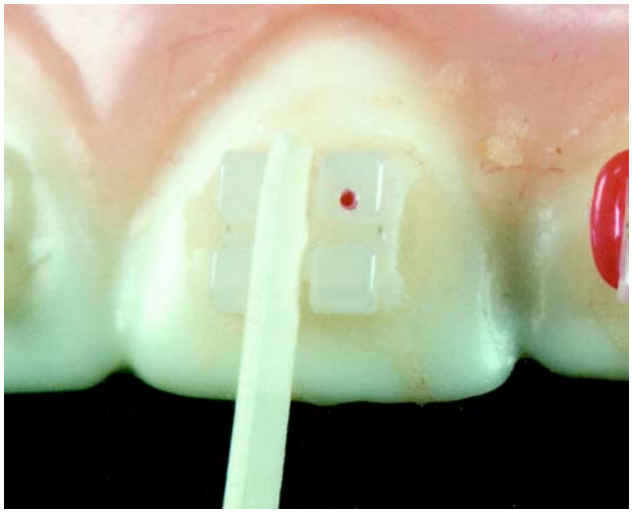
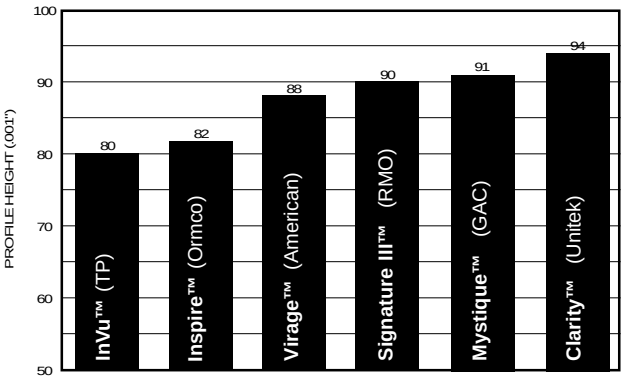


Figure 2. Good inter-tie wing clearance allows for easy bracket positioning.

Profile Height

InVu brackets have the lowest profile height of any ceramic bracket currently available. The profile heights of the various brackets in the InVu series are compared to other brackets in Table II. Profile height, especially for mandibular brackets should be kept low. The speed of enamel wear due to ceramic bracket attrition is well illustrated by J.B. Douglas in a clinical report.[3]

TABLE II. Profile Height of Ceramic Brackets (0.001")
• Measured on upper lateral brackets



Frictional Resistance – Archwire in Slot

Ceramic brackets traditionally show higher frictional resistance as compared to metal brackets. The InVu ceramic brackets are manufactured using an injection molding process, which produces an extremely smooth surface as compared to brackets that have machined surfaces (Figure 3) as verified by studies.[4]

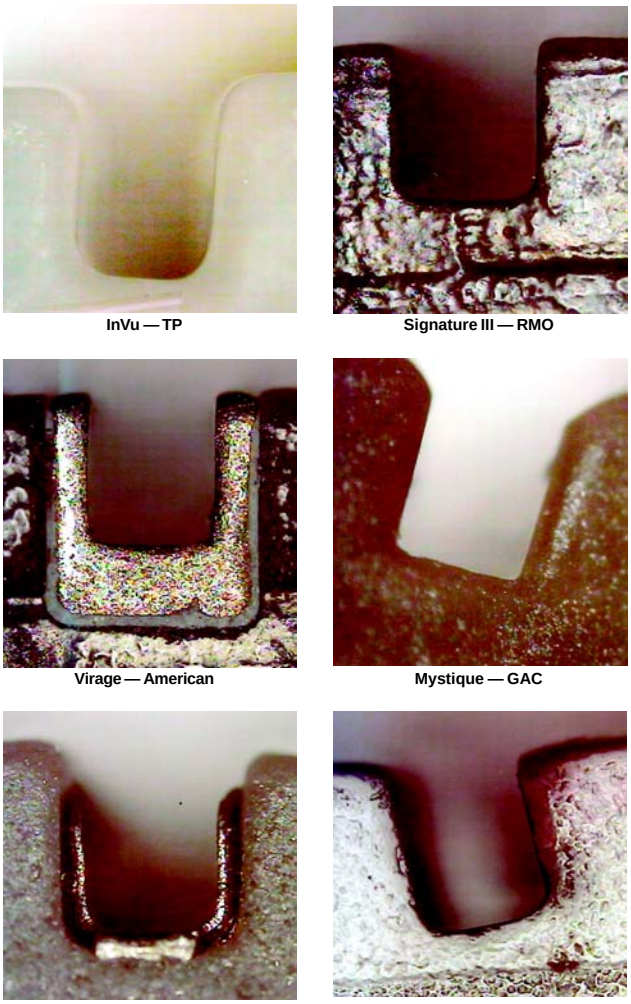


Figure 3. Comparison of smooth injection molded surface of InVu to rough machined surface of other ceramic brackets.

The smoother, injection molded InVu surface yields a lower friction force as compared to rough machined surfaces (Table III). InVu brackets have smooth rounded edges at the mesial and distal edges of the archwire slots to reduce static friction (Figure 4). Clarity and Virage brackets have a metal

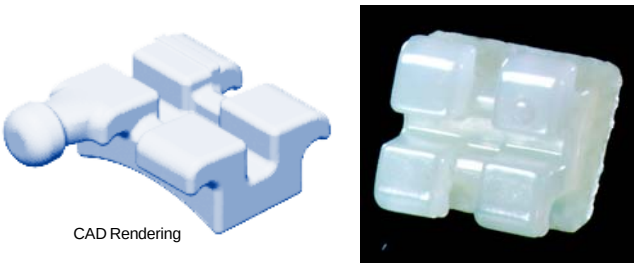


Figure 4. InVu has smooth radii at mesial/distal edges to prevent archwire entrapment.

insert in the archwire slot. The sharp edges of the metal insert can dig into the softer wire material and increase friction (Figure 5); thereby reducing tooth movement.

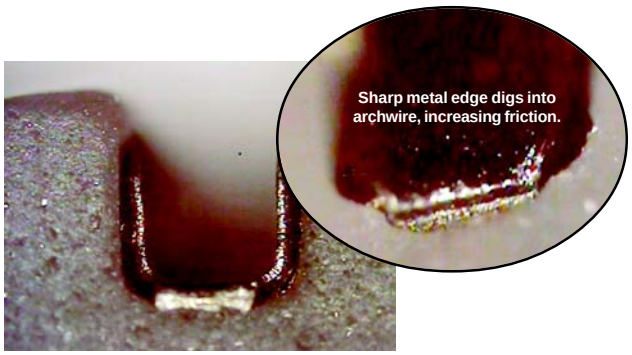


Figure 5. Brackets with metal inserts have sharp metal edges at mesial and distal ends of archwire slot.

Friction tests were conducted to evaluate the archwire slot/wire friction force for various brackets. Some manufacturers claim to achieve sliding friction equal to metal brackets, just by inserting a metal insert. The metal inserts introduce rough edges which are not found in metal brackets. This explains why some brackets with metal inserts actually do worse than metal brackets in sliding friction characteristics.

Friction Testing

Friction force was determined by pulling a 0.022" archwire through a ligated slot. Continuous irrigation (artificial saliva) simulated in-vitro lubrication. The strain rate was 0.12"/min with a travel length determined by establishment of equilibrium friction forces (Figure 6). The friction forces from various brackets are shown in Table III.

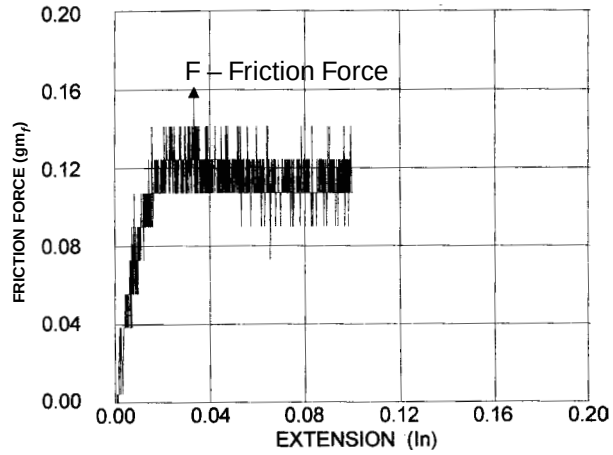
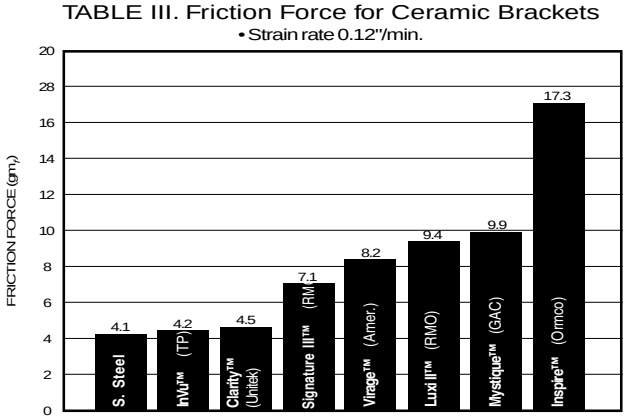


Figure 6. Friction Force Measurements

TABLE III. Friction Force for Ceramic Brackets



InVu™ – Advanced Bonding Mesh Base

InVu ceramic brackets have an advanced bonding base that replicates the mesh architecture of the mesh in metal brackets (Figure 7). This high strength, polymer mesh base provides for excellent mechanical and chemical bonding to most orthodontic adhesives. The superior bond strength of InVu is compared to other ceramic brackets in Table IV.

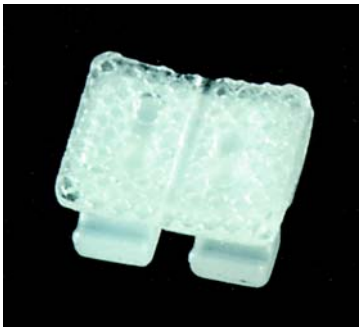
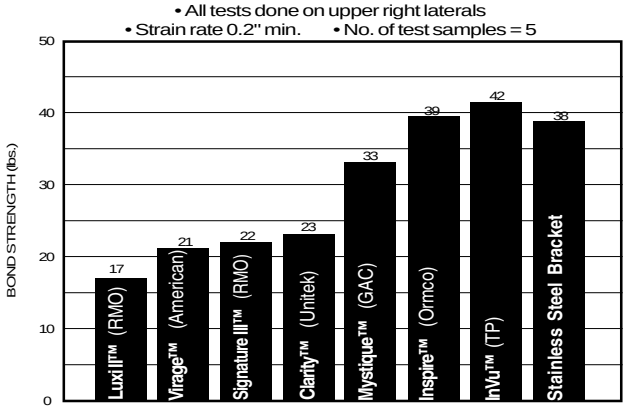


Figure 7.

TABLE IV. Bond Strength of Ceramic Brackets



Fatigue Testing of InVu™ Ceramic Brackets

Brackets are subjected to repetitive impact forces in the oral environment, leading to debonds; i.e., while biting on hard candy, getting hit at play, biting on a piece of steak, etc. These impacts subject the brackets to cyclic shear forces.[5] These in-vivo forces are simulated in an experimental set-up (Figure 8). A cyclic force of 20 pounds is applied to the InVu bracket, soaked for 24 hours in artificial saliva. The InVu bracket was the only bracket that withstood more than 7,000

cycles without debonding, establishing the superiority of the bond strength of the InVu crystal mesh base.

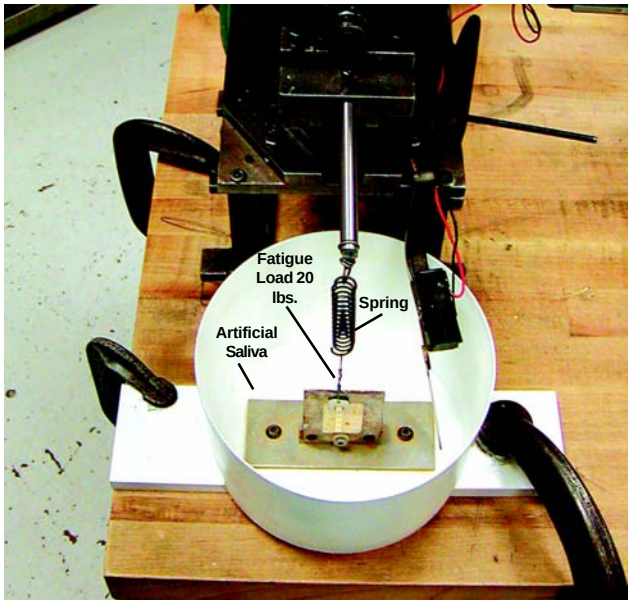
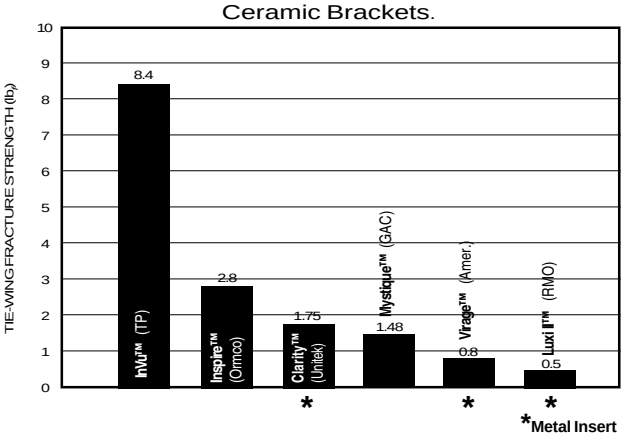


Figure 8. Fatigue testing of InVu Ceramic Bracket

Torsional/Tie-wing Fracture Strength

Tie-wings can easily fracture due to high-impact intraoral forces. High torsional forces are also experienced during transition to rectangular wires. In-vitro studies that compared shear forces needed to dislodge plastic and metal brackets, showed varying forces were encountered.[6] Depending on the shear bond strengths, the bracket would either debond or experience tie-wing fracture. InVu brackets have the highest tie-wing fracture strength. The smooth injection molded surfaces of the InVu bracket are flawless as compared to the rough machined surfaces. Surface flaws lead to cracks and fracture when the bracket is stressed. The addition of a metal insert does not improve the fracture strength (Table V and Figure 9).

TABLE V. Tie-Wing Fracture Strength of Various Ceramic Brackets.



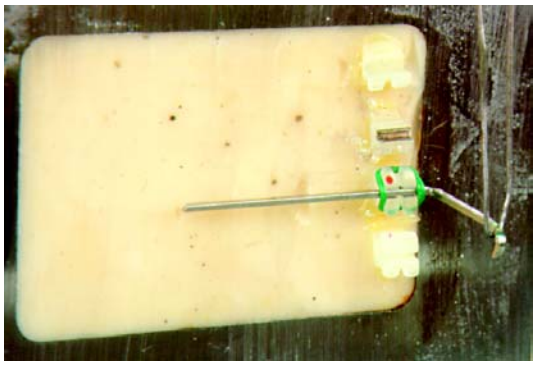


Figure 9. Torsional force testing of ceramic brackets

Conclusion:

InVu is a superior ceramic bracket that offers maximum performance at a value price point. It offers a low profile, twin design for maximum comfort and rotational control. It offers very low friction on par with metal brackets primarily because of its smooth injection molded surface. Binding of archwires on the mesial and distal edges of the slots is eliminated due to large radii at all mating edges. InVu offers the crystal mesh base, which has proven excellence in debonding over the past six years in thousands of patients. Being the only ceramic bracket that has a mesh base similar to metal brackets, excellent bond strength is achieved repeatedly. InVu ceramic brackets have addressed the major problems that orthodontists have experienced over the past 10 years, and are well on the way to setting new standards for excellence in clinical performance.

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