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FEATURES SECTION

# Current Products and Practice

# Aesthetic Orthodontic Brackets

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Due to an increasing demand for superior aesthetics during fixed appliance treatment, the use of aesthetic brackets has grown in popularity over recent years. Although often requested by patients, aesthetic brackets are not without their disadvantages. This article presents the currently available plastic and ceramic brackets and discusses the potential problems associated with each. Recent advances, introduced by manufacturers in an attempt to overcome their clinical disadvantages, are described.

*Key words*: Aesthetic brackets, ceramic/monocrystalline/polycrystalline brackets, plastic/polycarbonate brackets

## Introduction

Orthodontic patients, including a growing population of adults, not only want an improved smile, but they are also increasingly demanding better aesthetics during treatment. The development of appliances that combine both acceptable aesthetics for the patient and adequate technical performance for the clinician is the ultimate goal. There has been a recent trend towards the development of smaller stainless steel brackets but although these generally provide the technical performance required by the orthodontist the aesthetic advantage over conventional sized appliances is limited. Lingual orthodontics satisfies the aesthetic criteria but it can be argued that it produces a decrease in the performance of the appliance and considerable additional technical difficulties and time requirement for the orthodontist. A more recent addition to the orthodontist's armamentarium is Invisalign®. This aesthetically orientated technique uses a series of clear plastic aligners to treat simple to moderate alignment cases, especially in the adult patient. However, complex cases still require fixed appliance treatment and numerous brackets are now available for those clinicians and patients that are aesthetically orientated. Tables 1 and 2 give details of the currently available plastic and ceramic brackets.

## Plastic brackets

Plastic brackets were first marketed in the early 1970's. Initially constructed from acrylic and later polycarbonate, their acceptance by orthodontists as an aesthetic alternative to metal brackets was short lived. Inherent problems were soon noticed, including staining and odours but more importantly their lack of strength and stiffness resulting in bonding problems, tie wing fractures[1] and permanent deformation. Permanent deformation, or creep, occurs when a material is subjected to a constant load over an extended period of time and is particularly important for thermoplastic materials such as polycarbonate resins. Polycarbonate bracket slots distorted with time under a constant physiologic stress (2000gm.-mm) rendering them insufficiently strong to withstand longer treatment times or transmit torque.[2] In a simulated intra-oral situation Harzer *et al.*[3] reported significantly higher torque losses and lower torquing moments with polycarbonate brackets compared to metal brackets. They recommended that manufacturers should provide data on the distortion to be expected in polycarbonate brackets, which must be offset by additional torque, or that the bracket torque should be omitted from the technical specification.

To compensate for the lack of strength and rigidity of the original polycarbonate brackets, high-grade medical polyurethane brackets and polycarbonate brackets reinforced with ceramic or fibreglass fillers and/or metal slots have been recently introduced and are becoming increasingly popular. Polycarbonate brackets with metal reinforced slots demonstrate significantly less creep than conventional polycarbonate brackets[4] although torque problems still exist. Approximately 15% loss in torque over 24 hours has been observed with both ceramic reinforced and metal lined polycarbonate brackets.[5]

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**Table 1** Plastic brackets

| Bracket | Manufacturer/ Distributors | Composition | Prescription | Slot Size | Special Bonding | Special Features/ Manufacturers Claims |
|---|---|---|---|---|---|---|
| Aesthetik-Line® | Forestadent® www.forestadent.com | Filler reinforced composite | Roth<br>Standard-Edgewise<br>Standard-Ricketts | .018''<br>.022''<br>.018'' | Primer advised | Clear in colour<br>Roth first molar buccal tubes available |
| Alexander Spirit®MB | Ormco www.ormco.com | Composite with stainless steel reinforced slot | Alexander | .018'' | No primer needed, Ortho Solo™ universal sealant and bond enhancer advised | Single tie-wing with stainless steel slot<br>Adjustable metal rotation wing<br>Wedge design to minimize occlusal interferences and bracket wear<br>Ormco's Diamond™ bracket design and Face-Paint™ Identification System<br>Hooks standard on laterals |
| Avalon® | Ortho Technology® www.orthotechnology.com<br>The Dental Directory www.dental-directory.co.uk<br>DB Orthodontics Ltd www.dbortho.com | Medical grade polyurethane with silver alloy sliding guide | Roth<br>Standard Edgewise | .018''<br>.022'' | No priming agent required | Translucent<br>Biocompatible nickel free slot<br>Mechanical dovetailed base with "Micro Rock" coating<br>Compound contoured base and contoured tie wings<br>Colour coded ID system<br>Cuspid/bicuspid hooks available |
| Brilliant® | Forestadent® www.forestadent.com | Polyoxymethylene | Roth<br>Standard-Edgewise<br>Standard-Ricketts | .018''<br>.022''<br>.018'' | Chemical cure adhesives advised, no primer required | High colour stability, low friction and high wear resistance<br>Sandblasted mechanical lock base<br>Torque Protector to reduce root resorption<br>Brilliant® Bleached - lighter colour for bleached teeth (Roth)<br>Cuspid hooks available (Roth) |
| Classic™ | American Orthodontics www.americanortho.com | Metal reinforced urethane | Roth | .018''<br>.022'' | Same adhesive and bonding procedure as metal | 100% nickel free<br>Smooth, stain resistant and colour stable<br>Plastic material does not promote enamel abrasion<br>MicroRock™ dovetail mechanical lock base<br>Cuspid/bicuspid hooks available |
| Cosmetic Brackets | DB Orthodontics Ltd www.dbortho.com | Medical grade polyurethane | Roth | .022'' | No plastic primer needed | Colour fast and stain resistant<br>Micro rock fused base<br>Interlocking mechanical retention suitable with all adhesives<br>Cuspid/bicuspid hooks available |

**Table 1** *(Continued)*

| Bracket | Manufacturer/ Distributors | Composition | Prescription | Slot Size | Special Bonding | Special Features/ Manufacturers Claims |
|---|---|---|---|---|---|---|
| Damon™ 3 | Ormco<br>www.ormco.com | Clear composite resin and surgical grade stainless steel | Damon | .018''<br>.022'' | Ortho Solo™ universal sealant and bond enhancer advised | Passive self-ligating aesthetic bracket<br>Precision slide mechanism<br>Ultra-smooth contours and rounded edges<br>Slot with foursolid walls to facilitate fast, low-friction movement with maximum control<br>High retention mechanical bonding base<br>Cuspid/bicuspid hooks available |
| Elation™ | GAC International, Inc.<br>www.gacintl.com<br>TOC<br>www.tocdental.com | Polycarbonate with PET and metal slot | Roth Formula | .018''<br>.022'' | Ideal® 1 advised or a plastic primer with other adhesives | Transparent high quality plastic<br>Resistant to erosion and discolouration<br>Metal slot is embedded in the body of the bracket<br>Mechanical retention base<br>Cuspid/bicuspid hooks available |
| Elegance® SL (Super Lock) | Dentaurum<br>www.dentaurum.com<br>Hawley Russell & Baker Ltd.<br>www.hawleyrussell.com | Fibreglass reinforced polycarbonate with metal slot | Roth<br>Standard Edgewise | .018''<br>.022'' | No<br>If desired a optional chemical primer may be used | Transparent composite<br>Fully integrated metal slot<br>Contoured mechanical/chemical retention base<br>Rhomboid design with torque-in-base<br>Integrated metal cuspid hooks available (Roth only) |
| Envision™ and Envision™ GOLD SLOT | Ortho Organizers<br>www.orthoorganizers.com<br>Precision Orthodontics | Thermoplastic polyurethane +/− solid 18-carat gold alloy slot | Roth<br><br>Bio-Progressive | .018''<br>.022''<br>.018'' | No primer required, suitable with any adhesive | Nickel free<br>Heat treated for greater strength, sliding mechanics and hardness<br>Low profile design<br>Porous base with mechanical dovetail grooves<br>Compound contoured, torque-in-base design |
| Esthetys® Series | RMO®<br>www.rmortho.com | Polyurethane (CLASSIC) with optional gold slot (GOLD) | Standard Edgewise<br>Roth Straight Wire<br>Bio-Progressive | .018''<br>.022''<br>.0185'' | No primer required | Smooth friction-reduced finish<br>Resistant to discolouration<br>Low profile with easy ligation<br>Integrated hooks<br>Anatomically contoured silica treated base |

**Table 1** *(Continued)*

| Bracket | Manufacturer/ Distributors | Composition | Prescription | Slot Size | Special Bonding | Special Features/ Manufacturers Claims |
|---|---|---|---|---|---|---|
| IMAGE™ | Hawley Russell & Baker Ltd.<br>www.hawleyrussell.com | Glass reinforced composite | Roth (Standard Edgewise and Ricketts as special orders) | .018''<br>.022'' | No plastic primer, suitable with all adhesives | Stain resistant with the aesthetics of ceramic<br>Enamel wear virtually eliminated<br>Friction comparable to metal<br>Mechanical lock retention with torque-in-base<br>Cuspid hooks available |
| Miura | RMO®<br>www.rmortho.com | Plastic | Standard Edgewise | .018''<br>.022'' | Primer required | Available as single or twin wing, with or without a vertical slot<br>Molar tubes, lingual hooks and buttons available |
| Opal | Ultradent<br>www.ultradent.com<br>Opal Orthodontics<br>www.opalorthodontics.com | Polycrystalline polymer, highly filled with speciality glass | Roth | .022'' | Opal prime | Single piece, passive self-ligating bracket with self locking cap<br>Translucent, nickel free and stain resistant<br>Secondary slot (.018''x.018'')<br>Compound contoured chemical and mechanical base<br>Cap marking system for accurate placement and identification<br>Cuspid hooks as standard with auxiliary hooks available |
| OrthoFlex™ | Ortho Technology®<br>www.orthotechnology.com<br>The Dental Directory<br>www.dental-directory.co.uk | Medical grade polyurethane | Roth<br>Standard Edgewise<br>MBT version | .018''<br>.022'' | No plastic primer | Colour fast and stain resistant<br>Mechanical lock base with dovetail grooves and 'Micro Rock' coating<br>Cuspid/bicuspid hooks available |
| Oyster ELS™ | GAC International, Inc.<br>www.gacintl.com<br>TOC<br>www.tocdental.com | Copolymer | Roth Formula | .018''<br>.022'' | Plastic primer advised | Translucent, metal free self-ligating bracket<br>Patented snap-on cap<br>Mechanical lock base<br>Distal 'T' hook on cuspids<br>Exclusive use of Superelastic and Beta arch wires recommended |
| Plastic Standard Edgewise Bracket | Ortho Organizers<br>www.orthoorganizers.com | Plastic | Standard Edgewise | .018''<br>.022'' | Primer required | Strong, durable and stain resistant contemporary design<br>Smooth, rounded edges for patient comfort<br>Extra large tie wings for maximum strength |

**Table 1** *(Continued)*

| Bracket | Manufacturer/ Distributors | Composition | Prescription | Slot Size | Special Bonding | Special Features/ Manufacturers Claims |
|---|---|---|---|---|---|---|
| Polar™ and Polar Plus | Ortho Care (UK) Limited www.orthocare.co.uk | Medical grade polyurethane with or with an 18-carat gold alloy slot | Roth | .018'' .022'' | No primer | Translucent, colour fast and stain resistant<br>Injection molded and nickel free<br>Greater creep resistance<br>Compound contoured base<br>Mechanical retention with torque-in-base<br>Single wing lower incisors<br>Cuspid/bicuspid hooks available |
| Quantum™ | Masel www.maselortho.com | Composite | Roth | .018'' .022'' | Plastic primer required | Translucent cast bracket<br>Resistant to distortion and degradation<br>Mechanical locking base<br>Low profile design<br>Wide shatter resistant hooks available on cuspids/bicuspids |
| Silkon m™ | American Orthodontics www.americanortho.com | Plastic with "ceramic like" filler | Roth Style | .018'' .022'' | No need for silane or special adhesives | Injection molded<br>Non-porous stain resistant surface<br>Particle mechanical lock base<br>Gingival single wing on lower anteriors with super low profile<br>Cuspid/bicuspid hooks available |
| Spirit® MB | Ormco www.ormco.com | Composite | Level Arch Modern (Additional individual tooth options available) | .018'' .022'' | No primer, suitable with all adhesives | Mechanical "mushroom" bonding base comparable to steel mesh<br>Face-Paint™ Identification System<br>Cuspid/bicuspid hooks available |
| Synthesis Composite | Ortho-Byte www.ortho-byte.com | Medical grade polyurethane with or without a metal slot | Roth<br>Edgewise<br>Ricketts (metal slot only) | .018'' .022'' | No primer required | Injection moulded then heat treated to increase strength and durability<br>Low profile design with extended undercuts for easy ligation<br>Compound contoured mechanical lock base<br>Molded metal slot with hook extension |
| Vogue | GAC International, Inc. www.gacintl.com<br>TOC www.tocdental.com | Composite reinforced plastic | Roth Formula Standard Edgewise<br>MicroProgressive Formula (3x3 only) | .018'' .022'' .018'' | No primer needed | New generation plastic bracket with super smooth surface<br>Mechanical lock, torque in base<br>Roth buccal tubes and cuspid hooks available |
| Wild Spirit™ | Ormco www.ormco.com | Composite | Level Arch Modern Rx | .018'' .022'' | Ortho Solo™ universal sealant and bond enhancer advised | Glow in the dark<br>Unique bonding base creates a mechanical interlock similar to steel mesh base<br>Cuspid hooks available |

**Table 2** Ceramic brackets

| Bracket | Manufacturer/ Distributors | Composition | Prescription | Slot Size | Special Debonding | Special Features/ Manufacturers Claims |
|---|---|---|---|---|---|---|
| Acclaim™ | ClassOne Orthodontics<br>www.classoneorthodontics.com | Polycrystalline | Roth<br>Bio-Progressive<br>Standard Edgewise<br>Ricketts | .018''<br>.022''<br><br>.018'' | Ligature cutters recommended | Rounded slot base<br>Mechanical/chemical retention with bond enhancement coating<br>Reliance™ adhesive recommended but suitable with all adhesives<br>Cuspid/bicuspid hooks available |
| Allure® | GAC International, Inc.<br>www.gacintl.com<br>TOC<br>www.tocdental.com | Polycrystalline (99.9% alumina) | Roth Ovation<br>Standard Edgewise<br>MicroProgressive | .018''<br>.022''<br>.018'' | Bracket should be squeezed at the bracket/ tooth interface with debonding pliers | High translucency<br>Patented dimpled chemo/ mechanical base<br>Diamond cut reheated slot<br>High under tie wing radii<br>No mandibular bicuspids to prevent enamel abrasion<br>Patented double hooks available on cuspids/upper bicuspids |
| Aspire Gold Ceramic Brackets | Forestadent®<br>www.forestadent.com | Polycrystalline with gold alloy slot | Roth | .018''<br>.022'' | No | Transparent, stain resistant aluminium oxide surface finish<br>Contoured mechanical dovetail base<br>Suitable with all common bonding materials<br>Cuspid/bicuspid hooks available |
| Clarity™ | 3M Unitek<br>www.3MUnitek.com | Polycrystalline with metal-reinforced slot | MBT<br>Roth<br>Standard Edgewise<br>Higher Torque | .018''<br>.022'' | How or Weingart recommended | Translucent twin bracket<br>Patented metal slot, debond slot and stress concentrator<br>Microcrystalline bonding surface with mechanical lock base<br>APC™ II and bi-directional cuspid/bicuspid hooks available |
| Contour® | ClassOne Orthodontics<br>www.classoneorthodontics.com<br>DB Orthodontics Ltd.<br>(Roth only)<br>www.bdortho.com | Polycrystalline (99.9% alumina) | Roth<br><br>Single wing<br>Lewis/Lang<br>(Upper arch 3-3 only) | .018''<br>.022''<br>.018'' | Ligature cutters recommended<br>DB suggest band slitters | Injection molded 100% breakage resistant<br>Patented rounded archwire slot<br>Crystalline particle mechanical retention base<br>Low profile lower 3 × 3<br>Cuspid/bicuspid hooks standard on Roth |

**Table 2** *(Continued)*

| Bracket | Manufacturer/ Distributors | Composition | Prescription | Slot Size | Special Debonding | Special Features/ Manufacturers Claims |
|---|---|---|---|---|---|---|
| DCA ceramic bracket | DCA<br>www.dentalcorp.com | Polycrystalline (99.9% alumina) | Roth<br>Standard Edgewise | .022” | No | Impervious to stains and discolouration<br>Twin configuration, small silhouette with rounded edges<br>Compound contoured, mechanical lock base<br>No lower bicuspids available<br>Hooks on cuspids/upper bicuspids as standard |
| Delta Force® | Ortho Organizers<br>www.orthoorganizers.co.uk | Polycrystalline | Delta Force<br>Supertorque | .022” | No | Pleasing patient aesthetics<br>Variable force ligation<br>Sliding mechanics and friction controlled by varying the ligature placement<br>Easy bracket placement<br>Hooks as standard 5 × 5 |
| Desire | Ortho Care (UK) Limited<br>www.orthocare.co.uk | Polycrystalline with gold alloy slot | Roth | .022” | No | Translucent, compact bracket<br>Patented mechanical lock base for easy bonding and debonding<br>True torque-in-base<br>Cuspid/bicuspid hooks available |
| Eclipse™ | Masel<br>www.maselortho.com | Polycrystalline (99.9% alumina) | Roth | .018”<br>.022” | Ceramic bracket debonding pliers recommended | Translucent and stain resistant<br>Full twin, low profile design<br>Bevelled lower incisors<br>Full size anatomical base<br>Mechanical bonding surface<br>Reinforced tie wings<br>Cuspid/bicuspid hooks available |
| Encore! ™ | Ortho Technology®<br>www.orthotechnology.com | Polycrystalline with silver alloy slot (99.9% alumina) | Roth Rx<br>Standard Edgewise | .018”<br>.022” | No | Translucent with patented silver alloy lined slot for enhanced sliding mechanics<br>Compound contoured base with dovetail mechanical retention<br>Generous contoured tie wings<br>Colour coded ID system<br>Cuspid/bicuspid hooks available |

**Table 2** *(Continued)*

| Bracket | Manufacturer/ Distributors | Composition | Prescription | Slot Size | Special Debonding | Special Features/ Manufacturers Claims |
|---|---|---|---|---|---|---|
| Fascination® 2 | Dentaurum<br>www.dentaurum.com<br>Hawley Russell & Baker Ltd<br>www.hawleyrussell.com | Polycrystalline (>99.99% alumina) | Roth | .018"<br>.022" | No | Optimal translucency with excellent colour stability<br>Sintered process for smooth surfaces and rounded contours<br>Silane coated button structured base<br>Coloured positioning guides<br>Cuspid hooks available |
| Illusion Plus™ & Silver Slot Illusion Plus™ | Ortho Organizers<br>www.orthoorganizer.co.uk<br>Precision Orthodontics | Polycrystalline with or without a silver slot | Roth<br>Bio-Progressive (Illusion Plus™ only) | .018"<br>.022" | No | Fully translucent<br>Small, low profile design for patient comfort<br>Mechanical dovetail bonding base with porous surface<br>Torque-in-base and compound contoured design<br>Colour coded site guides<br>Integral cuspid/bicuspid hooks available |
| Inspire Ice™ | Ormco<br>www.ormco.com | Clear monocrystalline sapphire | Roth | .018"<br>.022" | Inspire Ice single-patient debonding kit | Transparent true twin bracket<br>Boron carbide tumbling process and ultra-smooth heat polished surface<br>Mechanical ball-base design with gingival ball-reduction<br>Tooth-specific pad contours<br>Face-Paint™ Identification System<br>Cuspid/bicuspid hooks available |
| Integra Ceramic | Ortho-Byte<br>www.ortho-byte.com | Polycrystalline (99.9% alumina) | Roth<br>Standard Edgewise | .018"<br>.022" | Ligature cutters or ceramic bracket debonding pliers recommended | Transparent, stain resistant low profile design<br>Mechanical retention with compound contoured base<br>Radiopaque<br>Cuspid/bicuspid hooks as standard |

**Table 2** *(Continued)*

| Bracket | Manufacturer/ Distributors | Composition | Prescription | Slot Size | Special Debonding | Special Features/ Manufacturers Claims |
|---|---|---|---|---|---|---|
| Intrigue™ | Lancer Orthodontics<br>www.lancerortho.com<br>Ortho Care (UK) Limited<br>www.orthocare.co.uk | Polycrystalline | Roth<br>Standard Edgewise | .018"<br>.022" | No | Translucent, tooth shaped bracket with smooth, rounded corners and generous tie wings<br>Mechanical groove retention<br>Torque-in-base<br>Colour coded site tabs<br>Cuspid/bicuspid hooks and gingival offset bicuspids available (Roth) |
| InVu® | TP Orthodontics<br>www.tportho.com | Polycrystalline with polymer crystal mesh base | Roth<br>MBT<br>Standard Edgewise | .018"<br>.022" | Ligature cutters recommended | Injection molded, low profile true twin design bracket<br>Smooth surfaces and contoured edges for comfort<br>Rounded archwire slot to reduce friction<br>Patented crystal mesh base protects enamel and debonds like metal<br>Ball-end cuspid hooks available |
| LUXI II™ | RMO®<br>www.rmortho.com | Polycrystalline with 18-karat (75%) gold insert | RMO® version of Roth | .018"<br>.022" | No | Translucent low profile twin design<br>Nickel free gold slot for strength and reduced friction<br>Patented dovetail mechanical retention with torque-in-base<br>Bevelled lower anteriors<br>Cuspid/bicuspid hooks as standard |
| Monarch™ | ClassOne Orthodontics<br>www.classoneorthodontics.com | Polycrystalline | Roth | .018"<br>.022" | Ligature cutters recommended | True twin wing bracket<br>Greater interbracket distance with improved rotational control, easy ligation and reduced friction<br>Cuspid/bicuspid hooks available |
| MXi® | TP Orthodontics<br>www.tportho.com | Polycrystalline with polymer crystal mesh base | MXi Straight-Edge®<br>MXi Advant-Edge®<br>(Both Roth)<br>MXi Tip-Edge®<br>MXi 256-Begg | .018"<br>.022"<br><br>.022" | Ligature cutters recommended | Injection molded with smooth surfaces and contoured edges<br>Rounded archwire slot to reduce friction<br>Patented crystal mesh base protects enamel and debonds like metal |

**Table 2** *(Continued)*

| Bracket | Manufacturer/ Distributors | Composition | Prescription | Slot Size | Special Debonding | Special Features/ Manufacturers Claims |
|---|---|---|---|---|---|---|
| Mystique® | GAC International, Inc.<br>www.gacintl.com<br>TOC<br>www.tocdental.com | Polycrystalline | Roth Ovation<br>MicroProgressive Rx<br>Standard Edgewise<br>Roncone Rx | .018''<br>.022'' | Mystique<br>346RT or<br>Mystique1026 | Translucent, stain resistant low profile brackets<br>Metal free, diamond cut silica-lined slot<br>Patented NSB base<br>Compound contoured with torque-in-base<br>No lower bicuspids to prevent enamel abrasion<br>Patented double omni hooks available on cuspids and upper bicuspids |
| Reflections™ | Ortho Technology®<br>www.orthotechnology.com<br>The Dental Directory<br>www.dental-directory.co.uk | Polycrystalline<br>(99.9% alumina) | Roth Rx<br>MBT Rx<br>Standard Edgewise | .018''<br>.022'' | No | Injection molded, transparent and stain resistant bracket<br>Mechanical dovetail groove retention with compound contoured base<br>Generous contoured tie wings<br>Colour coded ID system<br>Cuspid/bicuspid hooks available |
| Signature III™ | RMO®<br>www.rmortho.com | Polycrystalline | RMO® version of Roth<br>Standard Edgewise<br>Ricketts<br>Bio-Progressive | .018''<br>.022''<br>.018'' | No | Patented arch slot to reduce bracket fracture and friction<br>Patented mechanical dovetail retention with torque-in-base<br>Underwing notches for easy ligation<br>Cuspid/bicuspid hooks as standard with Roth |
| Transcend™<br>Series 6000 | 3M Unitek<br>www.3MUnitek.com | Polycrystalline | Roth<br>Standard Edgewise<br>High Torque/<br>Ricketts | .018''<br>.022''<br>.018'' | Transcend<br>series 6000<br>debonding<br>instrument | Smooth corners and edges for patient comfort<br>Underwire tie-wing protector<br>Microcrystalline lock base<br>Colour coded indicators<br>APC™ and cuspid/bicuspid hooks available |

**Table 2** *(Continued)*

| Bracket | Manufacturer/ Distributors | Composition | Prescription | Slot Size | Special Debonding | Special Features/ Manufacturers Claims |
|---|---|---|---|---|---|---|
| Virage™ | American Orthodontics www.americanortho.com | Polycrystalline (99.95% alumina) palladium gold alloy insert | Roth<br>MBT | .018''<br>.022'' | Remove flash then apply ligature cutters or bracket removers beneath the bracket pad | 100% nickel free diffusion bonded slot<br>Stain and fracture resistant<br>Comfortable smooth contours<br>Dovetail mechanical base<br>Bevelled lower anteriors<br>Strengthened cuspid/bicuspid hooks available |
| 20/40m | American Orthodontics www.americanortho.com | Polycrystalline | Roth<br>Standard Edgewise | .018''<br>.022'' | Remove flash then apply ligature cutters or bracket removers beneath the bracket pad | Translucent twin system with small base, smooth surfaces and rounded slot corners<br>Mechanical retention base<br>Bevelled lower anteriors<br>Streamline hooks available on cuspids/bicuspids (Roth only) |

However, the performance of these brackets is significantly better than polycarbonate brackets and they probably have the potential to challenge ceramic brackets with future development. When comparing torque deformation characteristics of seven commercially available plastic brackets against stainless steel brackets, Sadat-Khonsari *et al.*[6] showed that metal slot reinforced brackets were subjected to the lowest degree of deformation, followed by pure polyurethane, pure polycarbonate and fibreglass reinforced polycarbonate brackets. Ceramic reinforced polycarbonate brackets showed the highest deformation under torque stresses. The addition of ceramic and fibreglass in the plastic brackets also failed to improve the torque stability of the polycarbonate brackets and pure polyurethane brackets showed no significant difference from pure polycarbonate at optimal torque. A comparison with stainless steel brackets illustrated that plastic brackets are only suited for clinical application if they have a metal slot.

Self-ligating aesthetic brackets are a further recent development. Polycarbonate self-ligating brackets have been shown *in vitro* to generate significantly greater static and kinetic frictional forces than stainless steel self-ligating brackets but are comparable to conventional stainless steel brackets.[7]

## Ceramic brackets

Ceramic brackets were introduced in the 1980's, offering many advantages over the traditional aesthetic appliances. Ceramic brackets provide higher strength, more resistance to wear and deformation, better colour stability and, most important to the patient superior aesthetics (Figure 1). Ceramic brackets are available in a variety of morphologies including true Siamese, semi-Siamese, solid and Lewis/Lang designs and also various appliance systems including Begg and variable force ligation brackets. Many brackets are made by specialist ceramic manufacturers and sold under proprietary names by manufacturers of orthodontic products or orthodontic supply companies. Therefore, some brackets from different manufacturers may be almost identical products.

### *Ceramic bracket composition*

All currently available ceramic brackets are composed of aluminium oxide in one of two forms: polycrystalline or monocrystalline, depending on their distinct method of fabrication. The first brackets were milled from single crystals of sapphire (monocrystalline) using diamond tools.[8] These were closely followed by polycrystalline sapphire (alumina) brackets, which are manufactured

**Figure 1** Ceramic brackets (facial view)

and sintered using special binders to thermally fuse the particles together[9,10] (Figure 2). The most apparent difference between the two is their optical clarity: monocrystalline ceramic brackets being noticeably more translucent.

Polycrystalline zirconia brackets ($ZrO_2$), which reportedly have the greatest toughness amongst all ceramics, have been offered as an alternative to alumina ceramic brackets.[11] They are cheaper than the monocrystalline ceramic brackets but they are very opaque and can exhibit intrinsic colours making them less aesthetic. Good sliding properties have been reported with both stainless steel and nickel-titanium archwires[12] along with reduced plaque adhesion, clinically acceptable bond strengths and bond failure loci at the bracket/adhesive interface. However, Keith *et al.*[13] found no significant advantage of zirconia brackets over polycrystalline alumina brackets with regard to their frictional characteristics. As the clinical performance of alumina ceramic brackets has continued to improve over recent years, zirconia brackets have become obsolete and only alumina ceramic brackets will be considered further.

Ceramic brackets are not without their disadvantages including:

- Bonding and bond strength

**Figure 2** Polycrystalline ceramic brackets

- Frictional resistance
- Bracket breakage and fracture resistance
- Iatrogenic enamel damage
- Debonding

### *Bonding and bond strength*

Ceramic brackets cannot bond chemically with acrylic and diacrylate bonding adhesives due to their inert aluminium oxide composition. Consequently, the early ceramic brackets used a silane-coupling agent to act as a chemical mediator between the ceramic bracket base and the adhesive resins. This chemical retention resulted in extremely strong bonds that caused the enamel/adhesive interface to be stressed during debonding, risking irreversible enamel damage in the form of crack and delamination that often required dental restorations. Consequently, the challenge was to develop a bond between the ceramic bracket base and the enamel that clinically has adequate strength to accomplish treatment but can be broken at debond without damage to the enamel surface. The majority of the currently available ceramic brackets rely solely on mechanical retention, using standard light or chemically cured adhesives, without the need for additional special bonding agents. Numerous mechanical base designs are now available ranging from microcrystalline, mechanical ball, dovetail, dimpled chemo/mechanical, silane coated buttons and polymeric bases with many manufacturers claiming consistent bond strengths and debonding characteristics comparable to that of stainless steel mesh.

Several researchers have evaluated the bond strength of ceramic brackets with different retention mechanisms and concluded that mechanically retained brackets have adequate bond strength and appear to cause less enamel damage at debond compared to the chemically retained

variety.[14–16] Bond strength can also be modified by the choice of adhesive, different types of enamel conditioning[17] and different etch times.[18] The mean bond strength of metal reinforced brackets is reportedly significantly lower than conventional ceramic brackets and comparable with stainless steel brackets.[19]

### *Frictional resistance*

Unlike stainless steel brackets, ceramic brackets can vary in fracture toughness and strength depending on the extent of the surface roughness. This, in turn affects the overall frictional properties of the bracket. Polycrystalline ceramics, due to their rougher more porous surface, have a higher coefficient of friction than monocrystalline ceramics and stainless steel, which are comparable. Polycrystalline ceramic brackets are manufactured either by an injection moulding process, which produces a smooth surface texture, or by milling or machining with diamond tools, resulting in a rougher final surface texture. Omana *et al.*,[20] showed conclusively that machined ceramic brackets produce significantly greater frictional forces than injection moulded brackets. Even so, polycrystalline brackets generate significantly greater frictional forces than stainless steel brackets.[21,22] When clearances no longer exist between the archwire and the bracket slot, polycrystalline brackets demonstrate a rapid non-linear increase in resistance to sliding once second-order angulations increase above 4.8 degrees. Scratches on the archwire, with stainless steel debris on the outer slot wall edges, have also been observed.[22] Regardless of form, the frictional characteristics of polycrystalline ceramic brackets are worst with any archwire combination, whether bearing against stainless steel, nickel-titanium, cobalt-chromium or beta titanium archwires, when compared to stainless steel brackets.[23–26]

In an attempt to improve the frictional characteristics of polycrystalline ceramic brackets, manufacturers have introduced metal lined/reinforced archwire slots (Figure 3). They claim to provide smoother sliding mechanics and additional strength, to withstand routine orthodontic torque forces, whilst preserving the aesthetic appeal. Many different metal lined polycrystalline brackets are currently available (see Table 2 for details) with 18-carat gold inserts reportedly superior to stainless steel with regard to frictional resistance.[27] Researchers have shown promising results with stainless steel reinforced brackets, demonstrating competitive frictional forces to conventional stainless steel brackets[11,27] and self-ligating brackets. [11] Other studies have not reported such favourable results. Thorstenson and Kusy[22] found no significant difference in resistance to sliding between aesthetic brackets, with and without stainless steel inserts, when clearances exist between the archwire and the walls of the bracket slot. When clearances no longer exist, the frictional resistances for both brackets generally increase at a rate equal to or greater than stainless steel brackets. They concluded that the addition of stainless steel inserts to polycrystalline brackets did not considerably improve the resistance to sliding over those aesthetic brackets without inserts. Nishio *et al.*[28] demonstrated significantly higher frictional forces with ceramic brackets with metal slots compared to stainless steel brackets. The difference is probably due to the difficulty in adapting the metal insert to the ceramic slot and due to their different expansion coefficients. Cacciafesta *et al.*[29] found metal-inset ceramic brackets generated significantly lower frictional forces than conventional ceramic brackets, but higher forces than stainless steel brackets.

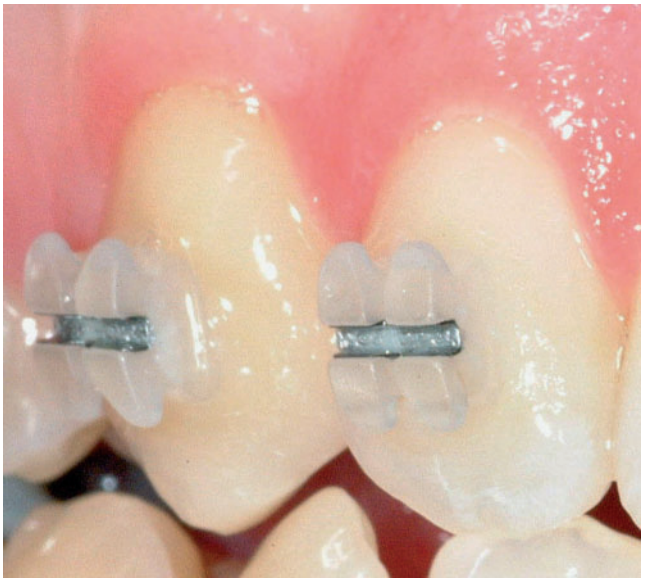

**Figure 3** Ceramic bracket with metal slot

In addition to the use of metal inserts, some manufacturers have attempted to reduce friction by use of a silica-lined slot to increase aesthetics and decrease friction (eg Mystique™). The diamond cut bracket slot is glazed with a silica treatment to eliminate imperfections. In addition, the slots' proximal edges are recessed to reduce abrasion between the archwire and the slot. Another recent modification to both ceramic and stainless steel brackets, designed to further reduce friction, is the introduction of bumps along the floor of the slot. Unfortunately, the bumps do not appear to reduce classical friction as ceramic brackets with a single bump to the slot floor produce similar rates of binding to the conventional design.[30]

*Bracket breakage and fracture resistance*

The low fracture toughness of ceramics leads to a higher incidence of bracket breakages than with stainless steel brackets. Product design and the manufacturing process are the two main factors determining the strength of ceramic brackets, with the design of the inner slot and tie wing being critical to the strength of the appliance. Tie wings can easily fracture due to the high torsional forces exhibited by rectangular wires and surface flaws within ceramic brackets can lead to cracks and fractures when the bracket is stressed. Injection moulded brackets have a much smoother finish than machined brackets thus reducing the number of surface flaws. Refined manufacturing techniques including boron carbide tumbling process (Inspire Ice™) and surface heat treatments may produce ultra-smooth surface finishes and rounded facial contours to improve frictional resistance and patient comfort.

*Iatrogenic enamel wear*

Ceramic brackets, being second in hardness only to diamond, are significantly harder than enamel. Rapid and severe enamel wear to the opposing dentition has been reported when ceramic brackets are placed in the lower arch.[31] Therefore, caution should be exercised to prevent contact of the ceramic bracket with opposing enamel surfaces. The use of polycarbonate brackets in the lower arch has been recommended if overbite is a concern as they are less abrasive to the opposing dentition. In response to the risk of iatrogenic enamel damage some manufacturers no longer produce lower bicuspid ceramic brackets and have developed low profile or bevelled brackets for the anterior mandibular segment. Elastomeric ligatures that cover the occlusal tie wing slot, thus preventing contact of the opposing dentition with the ceramic bracket, are a further method of reducing the risk of enamel damage. However, these are bulky and concerns exist over oral hygiene implications. Alternatively, most patients will accept metal brackets on the lower arch, particularly when shown that they will display little if any of the lower brackets during normal function (Figure 4).

In addition, bonding ceramic brackets to compromised teeth e.g. endodontically treated teeth, enamel hypoplasia and cracks, or those with large restorations should be avoided if possible, thus reducing the risk of tooth damage during bracket removal.[14]

*Debonding*

Due to their pliable nature, metal brackets can be removed safely and atraumatically from the tooth surface via distortion of the base. However, rigid ceramic brackets present a debonding challenge, with enamel damage more likely from debonding ceramic as opposed to metal brackets.[15] The sudden nature and the degree of force required to achieve mechanical bond failure of the early chemically bonded ceramic bracket, often resulted in enamel fractures and delamination. Alternatively, the brackets shattered leaving the base still attached to the enamel surface. Removal of the residual ceramic, using a diamond bur in a high-speed handpiece is both difficult and time consuming. Grinding ceramic materials from the tooth surface generates heat, resulting in potential pulpal damage especially if low speed grinding without a coolant is used.[32] Large ceramic fragments pose the risk of aspiration of the radiolucent material by the patient and produce ceramic dust that has been associated with skin and eye irritation.[33]

**Figure 4** Upper ceramic brackets opposed by lower metal brackets

Most ceramic brackets are now mechanically retained and many alternative debonding methods have been suggested, to avoid the complications associated with ceramic bracket removal. It is recommended that all excess flash be removed from the bracket/enamel interface prior to bracket debonding. Notching of the bonding adhesive prior to bracket placement has been

**Table 3** Ceramic bracket debonding techniques

| Debonding technique | Method | Advantages | Disadvantages |
|---|---|---|---|
| Debonding lift-off pliers | Gentle squeezing pressure at the bracket/adhesive interface to produce a tensile bond failure perpendicular to the tooth surface | Quick and simple<br>Standard orthodontic instrument<br>Safest and most effective technique for ceramic bracket removal[8] | Increased debonding force<br>Risk of enamel damage<br>Risk of bracket fracture and aspiration of fragments<br>Increased patient discomfort? |
| Hows or Weingart pliers and ligature cutters | Gentle squeezing pressure of the mesial and distal tie-wings at the bracket adhesive interface | Recommended by some manufacturers<br>Quick and simple<br>Standard orthodontic instrument | Archwires must be removed prior to debond<br>Risk of bracket fracture<br>Risk of aspiration of brackets or bracket fragments<br>Risk of enamel damage |
| Special debonding pliers | Special debonding pliers and single patient debonding kits are recommended by some manufacturers | Quick and simple<br>More consistent debonding<br>Reduced risk of enamel damage<br>Reduced risk of bracket fracture<br>Guards contain fragments of broken brackets | Often bracket specific<br>Additional expense of separate instruments<br>Brackets may still fracture<br>Enamel damage still possible |
| Electrothermal Debonding | Softening of the resin adhesive via a rechargeable heating gun inserted into the bracket slot whilst applying a tensile force to the bracket[37,38] | Reduced debonding force<br>Reduced risk of enamel damage[14,39]<br>Reduced incidence bracket fracture[14]<br>Reduced patient discomfort [35] | Risk of pulpal damage[41–44]<br>Risk of soft tissue burns<br>Expense of unit<br>Increased clinical time<br>Bracket failure may not occur at first attempt |
| Ultrasonic | Ultrasonic instruments used to create a purchase point within the adhesive between the bracket base and the enamel surface | Reduced debond force[45]<br>Decreased chance of enamel damage<br>Reduced incidence bracket fracture<br>Removal of residual resin with same instrument [14] | Time consuming<br>Excessive wear of ultrasonic tips<br>Water spray coolant required to minimise the detrimental heating effect on the pulp [27] |
| Laser | Irradiation of the buccal surface with laser light<br>Debonding occurs through thermal softening of the adhesive[46] | Reduced debonding force<br>Reduced risk of enamel damage[47]<br>Reduced incidence bracket fracture[48,46]<br>Potentially less traumatic and painful | Potential pulpal damage due to heat production[47]<br>Expensive units Laser hazards |
| Debonding agents | Based on peppermint oil derivatives | Reduced debonding force<br>Promote failure at the adhesive/enamel interface<br>Reduced enamel damage[32] | Questionable effect on the bond strength of the adhesive resins[49]<br>Increased clinical time<br>Additional expense of agent |

shown *ex vivo* to significantly reduce the mean and maximal debond forces thus eliminating ceramic bracket fracture. This technique may help facilitate the removal of ceramic brackets but it is demanding of clinical time and expertise.[34]

The following methods of debonding ceramic brackets have been described and their advantages and disadvantages are discussed in Table 3.

- Conventional debonding pliers
- Hows, Weingarts or ligature cutters
- Ceramic bracket specific debonding pliers
- Electrothermal debonding
- Ultrasonic scaler
- Laser aided debonding
- Debonding agents

Many manufacturers claim that current ceramic brackets debond as easily and as safely as metal brackets. 3M Unitek have patented a debonding slot and 'stress concentrator' located on the base of their Clarity™ bracket. The debonding slot concentrates stress at this point, causing the bracket to collapse under gentle pressure from How or Weingart pliers. This allows debonding in a similar method to metal brackets, with most of the residual adhesive remaining on the enamel surface.[35] The failure at the bracket/adhesive interface decreases the probability of enamel damage but necessitates the removal of more residual adhesive after debonding.[36] The patented crystal-mesh base of the MXi® and InVu brackets (TP Orthodontics) is squeezed with ligature cutters and the bracket reportedly releases from the tooth in the same manner as a metal bracket. The tensile forces generated during debonding claim to be much lower than those of conventional ceramic brackets and metal lined brackets as the polymeric base undergoes plastic deformation resulting in shear bond failure.[35] The failure at the bracket/adhesive interface decreases the probability of enamel damage but again necessitates the removal of more residual adhesive after debonding. It is important to consult the individual manufacturers' guidelines regarding their recommended debonding instructions for removal of their brackets.

## Conclusion

The superior aesthetics of ceramic and polycarbonate brackets compared to conventional stainless steel brackets are not only well accepted by patients, particularly adults, but are positively sought after. However, many clinicians are still less willing to accept aesthetic brackets due to their unfavourable clinical characteristics. In response, manufacturers have strived over recent years to address many of the clinicians' concerns. Since their introduction, product design and clinical performance of aesthetic brackets has greatly improved. Modification of the archwire slot, advances in bracket base design and refined manufacturing processes have, to a certain extent, tackled some of the problems of friction, strength and force control associated with aesthetic brackets. Further development and research is required, preferably in the form of prospective randomised clinical trials, which will ultimately result in aesthetic brackets that clinically perform in a truly comparable manner to the current 'Gold Standard' stainless steel brackets.

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