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Recent advancements in orthodontic brackets - A review

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Abstract

The technology used to make orthodontic products and materials has advanced at an exponential rate. Newer materials, methods, and designs are coming up on a daily basis. These products help the orthodontist to give the best functional and aesthetic results to the patients. Orthodontic brackets have evolved from Angle's era to the MBT brackets followed by lingual brackets. These brackets have made the life of the orthodontists much easier. As technology advances many more new materials and designs will be coming forward. The purpose of this article was to review the recent advancements in orthodontic brackets and how the science behind them helps the orthodontist in the day to day practice.

Keywords: Brackets, Ceramic, Self-ligating, Lingual

Introduction

Orthodontic patients, including a growing population of adults, not only want an improved smile, but they also want better aesthetics during treatment. The development of appliances that combines both acceptable aesthetics for the patient and adequate technical performance for the clinician is the need of the hour. 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 conventionally sized appliances is limited.(1) Lingual brackets are aesthetic 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.(2) Many new generations of brackets are coming up in the market. The rise of these brackets has occurred at a fast rate. The purpose of this review article was to highlight the recent advancements in orthodontic brackets and how they help the orthodontist to give better treatment aesthetically.

Ceramic Bracket

Ceramic brackets were introduced in the 1970'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. 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.(3) 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. These were closely followed by polycrystalline sapphire (alumina) brackets, which are manufactured and sintered using special binders to thermally fuse the particles together. The most apparent difference between the two is their optical clarity: monocrystalline ceramic brackets being noticeably more translucent. Polycrystalline zirconia brackets (ZrO), which reportedly have the greatest toughness amongst all ceramics, have been offered as an alternative to alumina ceramic brackets.(5) They are cheaper than the monocrystalline ceramic brackets but they are very opaque and can exhibit intrinsic colours making them less aesthetic.(6) Good sliding properties have been reported with both stainless steel and nickel-titanium arch wires along with reduced plaque adhesion, clinically acceptable bond strengths and bond failure loci at the bracket/adhesive interface. However, Keith et al.(7) found no 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.

Plastic Bracket

Plastic brackets were marketed in the early 1980'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 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. In a simulated intra-oral situation Harzer et al.[(2)] reported 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 fibre-glass fillers and/or metal slots have been recently introduced and are becoming increasingly popular. Polycarbonate brackets with metal reinforced slots demonstrate less creep than conventional polycarbonate brackets 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.

However, the performance of these brackets is 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[(3)] showed that metal slot reinforced brackets were subjected to the lowest degree of deformation, followed by pure polyurethane, pure polycarbonate and fibre glass reinforced polycarbonate brackets. Ceramic reinforced polycarbonate brackets showed the highest deformation under torque stresses. The addition of ceramic and fibre-glass 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 Bracket

A self-ligating bracket is a ligature less system with a mechanical device built-in to close-off the bracket slot. Secure engagement of the main arch wire into bracket may be produced by a clip mechanism replacing the stainless steel or elastomeric ligature. Both active and passive self-ligating brackets have been developed depending upon the bracket & arch wire interaction.[(8)] The evolution of self ligating brackets is shown in Table 1.

Table 1: History of Self-ligating brackets

System Year Introduced
Russell Lock 1935
Edgelok (Ormco) 1972
Mobil Lock (Forestadent) 1980
Speed (Strite Industries) 1980
Activa (“A” Company) 1986
Time (Adenta) 1994
Damon SL5 (“A” Company) 1996
Twinlock (Ormco) 1998
Damon 2 (“A” Company/Ormco) 2000
In Ovation (GAC) 2000
In Ovation R (GAC) 2002
Philippe (Forestadent) 2002
Smartclip (3M Unitek) 2004
Sure (Denrum) 2005
Quick (Forestadent) 2005
Damon 3MX (Ormco) 2006
Smartclip 2 (3M Unitek) 2006
In Ovation C (GAC) 2006
Clarity SL (3M Unitek) 2007
Smartclip 3 (3M Unitek) 2009

Advantages[(9)]

1. Secure & robust ligation
2. Reduced friction
3. Enhanced efficiency & ease of use
4. Reduced overall treatment time
5. Efficient alignment of severely irregular teeth.
6. Better plaque control & anchorage conservation
7. Reduced risk of operator & patient injury including “Puncture Wounds”.

Features of Self-ligating bracket[(10)]

Speed brackets: Speed brackets (Strite Industries Ltd., 298 Shepherd Avenue, Cambridge, Ontario, N3C IVI Canada) have remained in successful production since 1980. Earlier brackets had clips which could too easily be displaced or distorted. These drawbacks have been taken care of. These brackets don't have the familiar tie-wings (Fig. 1).

Activa brackets: Activa brackets (A Company, San Diego, CA) had a rotating slide, which therefore gave a concave inner radius to the labial surface of the slot. These increased slot depth reduced the labio-lingual alignment efficiency. The bracket is wider than the average bracket, which reduced the inter-bracket span with the consequent disadvantages. Tie-wings were absent and a different bonding base made bracket positioning more difficult.

Time 2 bracket: The time 2 bracket (Adenta Gmbh) has a clip that rotates into position around the gingival

tie wing and rotates towards the occlusal rather than the gingival wall of the slot.

DAMON SL Brackets: Damon SL brackets ("A Company, San Diego, CA) had a slide that wrapped around the labial face of the bracket. The launch of Damon brackets in the mid-1990s made a definite step forward in popularity of self-ligating bracket. Damon SL brackets had two significant problems— the slides sometimes opened inadvertently and they were prone to breakage.

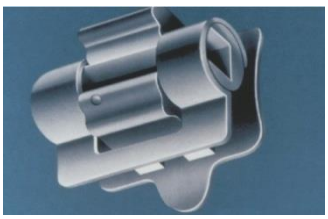
DAMON 2 Brackets: Damon 2 brackets (Ormco Corp.) were introduced to address the imperfections of Damon SL. Combined with the introduction of metal injection moulding manufacture & slight design changes, Damon 2 brackets are almost completely free from inadvertent slide opening or slide breakage. However, the brackets were not immediately and consistently very easy to open.

DAMON 3 and DAMON 3MX Brackets: Damon 3 and Damon 3MX brackets (Ormco corp.) have a different location and action of the retaining spring, and this has produced a very easy and secure mechanism for opening and closing. In addition, Damon 3 brackets are semi-aesthetic. However, early production of Damon 3 brackets suffered three significant problems: a high rate of bond failure, separation of metal from reinforced resin components, and fractured tie wings. These three problems received rapid and effective investigation and correction. Damon 3MX bracket is an all metal bracket with least problems

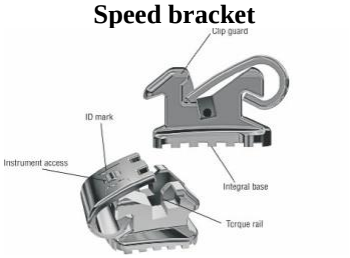
System R Brackets: System R brackets (GAC International Inc. 355 Knickerbocker Ave. Bohemia, NY11716) originally called In-ovation brackets, are very similar to the speed brackets in conception and design, but of a twin configuration with tie wings. In 2002, smaller brackets for the lower anterior teeth became available. In-Ovation R (Reduce, referring to the reduced brackets width) and this narrower width was effective in terms of greater inter bracket span. The bracket subsequently became known as system R. Some brackets of this type are difficult to open and this is more common in the lower arch where the gingival end of the spring clip is difficult to visualize. Excess composite at the gingival aspect of brackets in the lower arch can be difficult to see and may also hinder opening. Similarly, lace backs, under ties and elastomeric placed behind the arch wire are competing for space with the bracket clip. Both Speed and System R and also the similar and recently released Quick brackets (Forestadent) have addressed this difficulty by providing a labial hole or notch in the clip in which a probe or similar instrument can be inserted to open the brackets.

Smart Clip Brackets: The smart-clip brackets (3M unitek 3M Center, St. Paul, MN55144-1000) retains the wire by two C-shaped spring clips on either side of the bracket slots. The instruments or bracket pressure required to insert or remove an arch wire is therefore not applied directly to the clip, but to the arch wire, which in turn applies the force to deflect the clips and thus permits arch wire insertion or removal. This mechanism, therefore, has to cope with providing easy insertion and removal through the jaws of the clips but must also prevent inadvertent loss of ligation for both small, flexible arch wires and large stiff arch wires. With wider clinical use, it became apparent that the force required for insertion and removal of thick stainless steel wires from smart-clip brackets was uncomfortably high. A Recent edition of smart-clip brackets called as smart-clip 3 has addressed this difficulty by lowering the effective stiffeners of the spring clips. Smartclip is also available in all aesthetic ceramic brackets called as CLARITY –SL (with metal slots).

Speed bracket



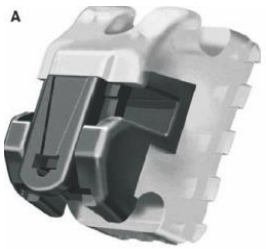
Activa bracket



Time 2 bracket

Damon SL bracket

Damon 2 bracket



Damon 3 and Damon 3MX bracket

System R bracket

Smartclip bracket

Fig. 1: Self Ligating Brackets

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.[11]

Lingual Brackets

Aesthetic has always been a catchword among patient. With more number of adult patients desiring orthodontic treatment, special aesthetic demands of the patient pose a great challenge to the orthodontic community. These patients have professional and social commitments and cannot accept 'visible braces' even for a short time. To be able to serve such patients, the orthodontic community comes out with the ultimate aesthetic solution – Lingual Orthodontics. Lingual Orthodontics, apart from offering the aesthetic benefit, also provides several mechanical advantages.[12] Since its inception in 1970, great advances have been made in the modality. At present, Lingual Orthodontics is a complete system in itself and encompasses accurate diagnosis, treatment protocol, clinical and laboratory procedures. Among the unique features of this appliances were a bite plane incorporated in the maxillary anterior brackets, mesh bonding pads designed to adapt to the lingual surface of the teeth, and pre-torqued arch wire slots based on a conversion of commonly used labial torque values.[13]

Description of the Appliance

The most significant change in design is the size of the bracket. The new lingual brackets are smaller and more closely adapted to the lingual vestibule. The dimensions of the incisor and canine brackets are 2.5 mm (width) by 1.5 mm (thickness).[14] The premolar and molar brackets have a thickness of only 1.5 mm (Fig. 2).

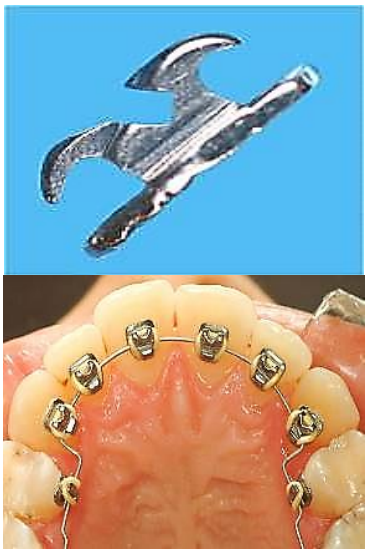


Fig. 2: Lingual Brackets

The shape of the bracket has also been dramatically changed. There are three small wings (two occlusal and

one gingival) and a 0.018" x 0.025" slot for the arch wire. The absence of a hook and bite plane further reduce the overall dimensions of the bracket leading to greater patient comfort.[15]

Butterfly brackets

In 1996, the American Board of Orthodontics (ABO) described the most common mistakes found in case reports presented by candidates failing the Phase III examination.[16] These cases most likely represent fairly common errors facing a significant number of orthodontists. As straight wire appliances are so popular today, perhaps some of these ABO concerns could be directed to limitations of the straight wire concept and its clinical use. It seems reasonable that improvements in the straight wire concept may help to reduce the prevalence of these errors. Making use of Andrews' original concepts was an important first step in the development of the Butterfly system, but we needed to focus on modifications and enhancements.[17]

Basis of Butterfly system

The Butterfly System is based on a new low-profile pre-adjusted bracket that features a vertical slot. The vertical slot adds versatility to the appliance by permitting the addition of a variety of auxiliaries (Fig. 3).

Fig. 3: Butterfly System features low-profile miniature bracket with vertical slot

Hook or T-pins for elastics can be added to the vertical slot during treatment whenever they are needed. This eliminates the need to have brackets manufactured with hooks. A further enhancement to patient comfort and aesthetics is derived from the reduced profile or thickness of the bracket, its miniature Siamese twin design, and rounded tie-wings. Combining these features with the elimination of hooks results in an appliance that is more comfortable, aesthetic and hygienic (Table 2).[18]

Features of the butterfly bracket system[19]

There are seven unique features designed to improve upon existing pre-adjusted appliance concepts (Fig. 4):

1. Progressive posterior torque,
2. Reversible 2nd premolar angulation,
3. Preventative mandibular anterior torque,
4. Mandibular anterior progressive angulation,
5. Convertible molar tubes with -6° angulation pre-welded on the band, and
6. Added versatility for both non-extraction and extraction treatments.
7. The versatile and indispensable vertical slot demonstrates a largely untapped potential.

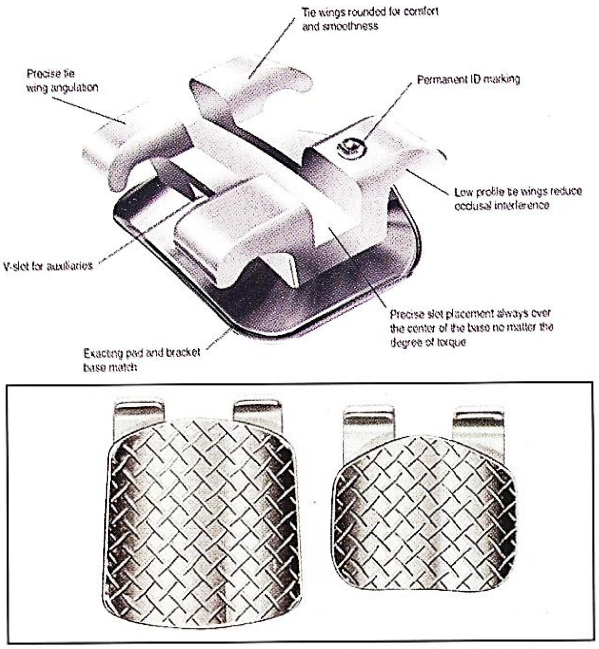


Fig. 4: Optional Offset and Standard Butterfly System premolar brackets. Offset pads increase surface area to enhance bond strength

Table 2: Butterfly system prescription

	Torque	Angulation	Rotation
Maxillary			
Central incisor	+14	+5	0
Lateral incisor	+8	+9	0
Canine	0	+9	0
First premolar	–7	0	0
Second premolar	–8	+3	0
Mandibular			
Central incisor	–5	+2	0
*Central incisor	–10	+2	0
Lateral incisor	–5	+5	0
*Lateral incisor	–10	+5	0
Canine	–3	+6	3 D/O
First premolar	–7	0	0
Second premolar	–9	+3	0

*Optional prescriptions.

Importance of the vertical slot[20]

The addition of a simple v-slot opens an entirely new realm of treatment options and auxiliaries. First of all, the elimination of ball hooks on the brackets

significantly reduces the potential tissue impingement, reduces trapped food and plaque, while making arch wire tie-in easier. Besides, a simple T-pin can be added and subtracted anywhere along your appliance when elastics are needed. This virtually eliminates the need for Kobayashi ties or soldered hooks. In addition, a variety of other v-slot auxiliaries is already available including rotating springs, uprighting springs, and power arms for retraction. One of the simplest uses of the v-slot is for teeth that are blocked-out or ectopically erupted. In these instances it is nearly impossible to tie an arch wire into the brackets during early alignment, however, a steel ligature or elastic thread can be placed through the vertical slot to "sling-tie" out and around the arch wire (Fig. 5).[20]

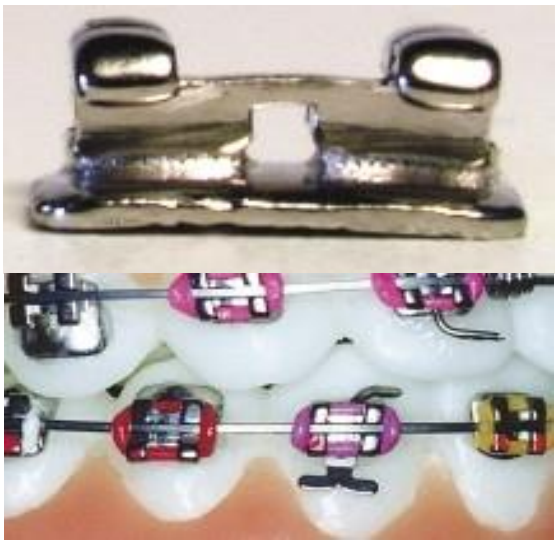


Fig. 5: Removable T-Pins or hook pins can be placed through vertical slots of any brackets when needed, eliminating integral bracket hooks

The various methods by which the Butterfly System addresses the most common problems described by the American Board of Orthodontics can be explained. Progressive posterior torque was designed into the Butterfly prescription to address improper bucco-lingual inclination of posterior teeth, the most prevalent error found by the ABO. These errors would seem to be common considering the extreme amount of mandibular posterior lingual crown torque "designed-into" many straight wire prescriptions, in part, to obtain so-called "cortical anchorage". Compounding this dilemma is the increasingly common use of expansion treatment (often using over expanded arch blanks) with a prescription that generally features a limited amount of maxillary posterior lingual crown torque. Increased maxillary posterior torque was added to the Butterfly prescription to reduce buccally-tipped molars while reduced mandibular posterior torque is intended to diminish the typical "rolling- in" or linguo-version of mandibular molars that are often seen with straight wire treatments. The combined effect is an improvement in the final buccolingual occlusion by flattening the Curve of Wilson, minimizing posterior over jet, and reducing the prominence of palatal cusps.

If additional posterior torque is to be added or subtracted during treatment, then Beta-Ti wires with 3rd order progressive torque appear to be the most effective and comfortable method compared to using stainless steel wires. By selecting an arch form that demonstrates a more anatomically correct shape (e.g., Natural Arch III) inter cuspal widths are maintained and, with appropriate arch coordination, the arch form will approach the original dimensions of the patient's dental arches (for better post treatment stability and natural aesthetics).[20]

Conclusion

The article summarizes the recent advancements in orthodontic brackets along with a detailed description of the self-ligating bracket, lingual bracket, and the new Butterfly system. As technology advances soon these brackets will also be obsolete and newer ones would take their place. Keeping up with the technological advancement is a tough job. The rise in quality also comes with a rise in its cost. The orthodontist should wisely choose which bracket system would be best for the selected case and also fulfill the aesthetics requirements of the patient.

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