

SELF LIGATING BRACKETS: THE PRESENT AND FUTURE

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ABSTRACT: Self-ligating brackets encompass fast popularity over the past several decades and had various advantages with regard to the efficiency, effectiveness, and stability of treatment when compare with conventional brackets. Self ligating brackets are basically two main types, according to the design of the locking mechanism, the dimensions of the slot, and the dimensions of the arch wires; they are passive and active. Active self-ligating brackets have a spring clip that stores energy to press against the archwire for rotation and torque control. Self-ligating brackets appear to be the beneficiary of the most recent studies as their design and engineering can offer the clinician the ability to take advantage of our better understanding of arch wire/bracket interactions. Since we know the impact of different bracket –arch wire combinations on the resistance to sliding, it is now possible for us to select the best combination depending upon the case.

KEYWORDS: Self –ligating brackets, active clip, passive slide, self-ligating lingual brackets, efficiency, effectiveness, stability.

INTRODUCTION

Efficiency has become a key word in defining the benefits of orthodontic appliances and techniques, allowing the patient to expect more efficient and timely treatment. Efficiency is said to be influenced by three key factors: efficiency of mechanics, decreased chair time per office visit, and fewer appointments to complete treatment. More recent data support the ability of self-ligating bracket systems to decrease chair time and overall treatment time.^{1,2,3}

A revolutionary change in the history of brackets was the introduction of the self-ligating brackets. The first self-ligating bracket, the Russell attachment, was developed by a New York orthodontic pioneer, Dr. Jacob Stolzenberg⁴, in the early 1930s. This bracket had a flat-head screw seated snugly in a circular, threaded opening in the face of the bracket. The mechanism of this revolutionary bracket was in stark contrast to the traditional approach of tying steel ligatures tightly around each bracket. And for those patients of Dr. Stolzenberg's who were fortunate enough to receive the Russell brackets, treatment was considerably more comfortable, with shorter office visits and shorter overall treatment time.⁵ Perhaps because Dr. Stolzenberg was ahead of his time, the concept of self-ligating brackets fell more or less into obscurity until the early 1970s. Since 1970, there has been a constant endeavor to perfect self-ligating brackets and several brackets were introduced (Table-1). Self-ligating brackets are supposed to be advantageous

in that they provide greater patient comfort, reduced friction between bracket and arch wire, shortened treatment time and reduced chair time.⁶ They offer more precise control of tooth translation, reduced overall anchorage demands, rapid alignment and more certain space closure.⁷ There is reduced incidence of soft-tissue lacerations, improved oral hygiene, less chance of cross infection risk and better esthetics.¹

The greatest virtue of self-ligating brackets is reduced friction. In orthodontic sliding mechanics, friction is determined by the type of arch wire, the type of bracket and the method of ligation.⁸ In the Passive self-ligating system, there is no actual contact of the clip with the arch wire, whereas in active system, friction is produced as a result of the clip pressing against the arch wire.

Modern manufacturing techniques and better design have produced a variety of robust, reliable, effective, and easy to use brackets. Another area of interest is the quality of result produced by self-ligating brackets. Quality in health care was defined by Lohr⁹ in 1990 as the extent to which health care services (interventions) increased the likelihood of desired outcomes consistent with professional knowledge. Health care should be safe, timely, efficient, effective, equitable, and patient centered.¹⁰ Self-ligating brackets have purported advantages in efficiency, effectiveness, and patient centeredness.¹¹

DEFINITION AND CLASSIFICATION OF SELF-LIGATING BRACKETS

A self-ligating bracket is defined as 'a bracket, which utilizes a permanently installed, movable component to entrap the arch wire'. The term "self-ligating bracket" is used for brackets that incorporate a locking mechanism (such as a ring, spring, or door mechanism) that holds the arch wire in the bracket slot.¹²

Classification of self-ligating brackets:

Self-ligating brackets are essentially two main types, depending on the design of the locking mechanism, the dimensions of the slot, and the dimensions of the arch wires:

1. Passive brackets
2. Active brackets

Passive: Passive brackets use a rigid, movable component to entrap the arch wire. Tooth control with passive brackets is determined solely by the fit between bracket slot and arch wire. As a result, tooth control frequently is compromised with undersized wires housed in what is essentially an arch wire tube. The impact of this reduction on the level of tooth control early in treatment has been lessened by the advent of nickel-titanium wires, but this can create problems later in treatment when stiffer wires are difficult to engage.

Ex: Damon, Mobil-Lock, Damon System, Ormco Corporation, Orange, California; and Discovery SL, Dentaaurum Ltd., Ispringen, Germany.

Active: Active brackets use a flexible component to entrap the arch wire. This flexible component constrains the arch wire in the arch wire slot and has the ability to store and subsequently release energy through elastic deflection. This gentle action imparts a light but continuous level of force on the tooth and its supporting structures, resulting in precise and controlled movement. The homing action of the flexible component may be described as the ability of the bracket to reorient itself and its accompanying tooth in three dimensions until the arch wire is seated fully in the arch wire slot, the "home" position. Any subsequent rotation, tipping or torquing during tooth movement of any kind results in the labial deflection of the flexible component and reactivates this homing behavior.

Ex: Speed, In-Ovation, Quick, Forestadent Ltd., Pforzheim, Germany; SPEED, Strite Industries, Cambridge, Ontario, Canada.

Active clip or Passive slide?^{13,14}

This is an issue that has fascinated intense debate and, as is seen in the subsequent articles in this issue, continues to be stressed by many producers and advocates of particular brackets as a major feature of importance.¹⁵

Thin aligning wires smaller than 0.018 inch diameter

The potentially active clip will be passive and irrelevant, unless the tooth (or part of the tooth if it is rotated) is sufficiently lingual placed in relation to a neighboring tooth that the wire touches the active spring clip. In that situation, a higher total force will usually be applied to the tooth in comparison to a passive clip. Even if there is no significant clip deflection, there is still a force on the wire which would not exist with a passive clip because the active clip effectively reduces the slot depth from 0.027 inch (the depth of a Damon 2 slot) to approximately 0.018 inch, either immediately if the clip is not deflected or as the wire becomes passive if it is initially deflected. This additional force is unlikely to be detrimental with modern low modulus wires but should be borne in mind, since several studies,^{16,17} have shown that only large deflections are likely to enable a super-elastic wire to show a plateau of force for a range of deflection. For teeth that are initially positioned lingual to their neighbors, the active clip can bring that tooth more labial (up to a maximum of $0.027 - 0.018 = 0.009$ inch) with a given wire. These figures are slightly complicated by the fact that the active clip does not reduce the slot depth to the same extent over the whole height of the slot - the clips on Speed, Time, and In-Ovation brackets impinge into the slot more at the gingival end than at the occlusal. This asymmetry would make a difference with small diameter wires depending on the relative vertical positions of neighboring teeth. The effect of having an active clip at this early stage of treatment can be thought of as having a potentially shallower bracket slot.

Wires larger than 0.018 inch diameter

An active clip will place a continuous lingual force on the wire even when the wire has gone passive. On teeth that are whole or in part lingual to a neighboring tooth, the active clip will again bring the tooth (or part of the tooth if rotated) slightly more labial than would have been the case with a passive clip at 0.027 inch slot depth. The maximum difference will be the difference between the labio-lingual dimension of the wire and 0.027 inch. For a typical 0.016×0.022 inch intermediate wire, this would give a maximum difference of 0.005 inch. 0.016×0.025 inch nickel titanium wires are recommended as the intermediate aligning wire for Damon 2 and this wire reduces this potential difference to 0.002 inch. Lingually placed teeth would have a slightly higher initial force with an active clip and wires of this intermediate size. With an active clip, an active force will remain on the wire, even when it is passive.¹⁴

Thick rectangular wires

An active clip will probably make a labio-lingual difference in tooth position of 0.002 inch or less, which is very small and unlikely to be of clinical significance. The suggestion that continued lingual directed force on the wire from an active clip (or from a conventional ligature) will cause additional torque from an undersized wire is

interesting and probably reflects a degree of misunderstanding about the generation of torque in an edgewise slot. whatever the orientation or shape of the rectangular wire, the clip places a diagonally directed lingual force on the wire, which does not contribute to any third order interaction between the wire corners and the walls of the bracket slot, which is the origin of torquing force. In fact, the need for an active clip to invade the slot reduces the available depth of one side of the slot and this means the rectangular wire is not fully engaged. This increases the 'slop' between the rectangular wire and the slot, and also reduces the moment arm of the torquing mechanism.¹⁸ Errors in torque can appear as errors in height or as labio-lingual contact point errors. Speed brackets have recently addressed this problem on upper incisors by extending the gingival walls of the slot either side of the clip as 'torquing rails'.

Overall advantages or disadvantages of an active clip

The actual clinical consequences of having a potentially active clip impinging into the slot are perhaps harder to assess than a first thought suggests. It is probable that with an active clip, initial alignment is more complete for a wire of given size to a clinically useful extent. However, with modern low modulus wires it should be possible to insert thicker wires into a bracket with a passive clip and arrive at the working arch wire size after the same number of visits,^{7,19} i.e., to store all the force in the wire, rather than dividing it between wire and clip. Once in the thick working arch wire, the potential disadvantages of an active clip are increased friction and reduced torquing capacity in one direction. To put the friction levels in context, these higher friction forces are still much lower than those found with elastomeric 'ligatures on a conventional tie-wing bracket.²⁰ All other factors being equal, higher friction is a disadvantage, which leads to the loss of clinical performance. Finally, there are the questions of robustness, security of ligation and ease of use.

HISTORY AND EVOLUTION OF SELF-LIGATING BRACKETS

With the introduction of Edward Angle's edgewise appliance, the orthodontic ligatures became the integral part of modern clinical orthodontics. Since that time orthodontic ligatures has come in many variations in design and materials.

Stainless Steel Ligatures

They are cheap, robust, and essentially free from deformation and degradation, and to an extent they can be applied tightly or loosely to the arch wire. They also permit ligation of the arch wire at a distance from the bracket. These wire ligatures have substantial drawbacks, and the most immediately apparent of these are the length of time required to place and remove the ligatures. One typical study²¹ found that an additional 11 minutes was required to

remove and replace two arch wires if wire ligatures were used rather than elastomeric ligatures. Additional potential hazards include those arising from puncture wounds from the ligature ends and trauma to the patients' mucosa if the ligature end becomes displaced.

Elastomeric Ligatures

Elastomeric ligatures became available in the late 1960s and rapidly became the most common means of ligation, almost entirely because of the greatly reduced time required to place and remove them when compared with steel wire ligatures. Elastomerics frequently fail to fully engage an arch wire when full engagement is intended. Khambay et al.²⁰ quantified the potential seating forces with wire and elastic ligatures and clearly much higher arch wire seating forces available with tight wire ligatures. A second and well-documented drawback with elastomerics is the substantial degradation of their mechanical properties in the oral environment.^{22,23}

Begg Pins

In the 1950s, Raymond Begg, a earlier student of Edward Angle, developed his light wire technique using Angle's ribbon arch brackets with round arch wires.²⁴ A key feature of the technique was the use of brass pins as the method of ligation. Begg pins had none of the disadvantages of elastomeric rings and were probably more rapid to place and remove than wire ligatures.

Recent appliances, ligature less appliances or self-ligating appliances has come to forefront of orthodontic world. Elimination of ligatures offers many benefits and few disadvantages. Since the first self-ligating bracket was designed in early 1930's, many designs have been patented, although only a minority has become commercially available. Table -1 is not exhaustive but includes a majority of the brackets produced commercially.

FORD LOCK

J. W. Ford was the first to manufacture Ford Lock self-ligating bracket in 1933. It featured a circular ring to create a rigid wall to entrap the arch wire in slot. As the circular member was incapable of interacting with arch wire for rapid tooth movement, Ford bracket turned to be a passive self-ligating bracket.

EDGELOK™

In the early 1970's orthodontic pioneer J. Wildman introduced a passive SLB called Edgelok bracket, marketed by the Ormco Corporation. This attachment was unique as it was the 1st self-ligating bracket to receive the wide spread commercial exposure. It featured a rigid movable cap which served to entrap the arch wire.

One of the advertised benefits of Edgelok design was that it permitted immediate free movements of the arch wire within the arch wire slot as with all passive design this free

Table 1: Self-ligating Brackets by Year/ Manufactures

Manufacturer	Bracket	Year
	Russell Lock	1935
Ormco	Edgelok	1972
Forestadent	Mobil-Lock	1980
Forestadent	Begg	1980
Strite Industries	SPEED	1980
"A" Company	Activa	1986
Adenta	Time	1996
"A" Company	Damon SL	1996
Ormco	TwinLock	1998
Ormco/"A" Co.	Damon 2	2000
GAC	In-Ovation	2000
Gestenco	Oyster	2001
GAC	In-Ovation R	2002
Adenta	Evolution LT	2002
Ultradent	OPAL	2004
Ormco	Damon 3	2004
3 M Unitek	SmartClip	2004
Ormco	Damon 3 MX	2005
Forestadent	Quick	2006
Lancer	Praxis Glide	2006
Class 1/Ortho Organisers	Carrière LX	2006
GAC	In-Ovation C	2006
3M Unitek	Clarity SL	2007
American Orthodontics	Vision LP	2007
Dentaurum	Discovery SLB	2007
Ortho Technology	Lotus	2008
Ormco	DamonQ,Damon aesthetic	2009
Ortho Classic	Axis	2009
3 M Unitek	SmartClip SL3	2009
Ormco	Damon Clear	2010
Forestadent	BioQuick, BioPassive	2010
3 M Unitek	Victory Series¹™	2011
American Orthodontics	Empower	2011

movement combined with narrow width of the bracket resulted in limited tooth control. Auxillary rotational collars were introduced quickly in attempt address this limitation but this combined with bulky bracket body contributed to its decline. The bracket was taken off the market in little less than 10 years after its introduction.²⁵

SPEED™:

G.H. Hanson in 1973 began work over this new self-ligating appliance, which is a trade mark of Strite industries Ltd. **SPEED** stands for **S**pring- loaded, **P**recision, **E**dgewise, **E**nergy, and **D**elivery. According to Hanson, the SPEED bracket can save as much as 5 minutes/arch change and that it permits a high degree of precision in the three dimensional control of tooth movement, that is well suited for

sliding mechanics and that it has a capacity to store large amounts of energy release at a slow rate. This active self-ligating design featured a curved flexible spring which could be moved in either of two equilibrium positions. Slot was slide open to permit arch wire insertion or slot closed to permit entrapment. The SPEED design was unique as its design could interact with arch wire in gentle corrective tooth movement.^{26,27}

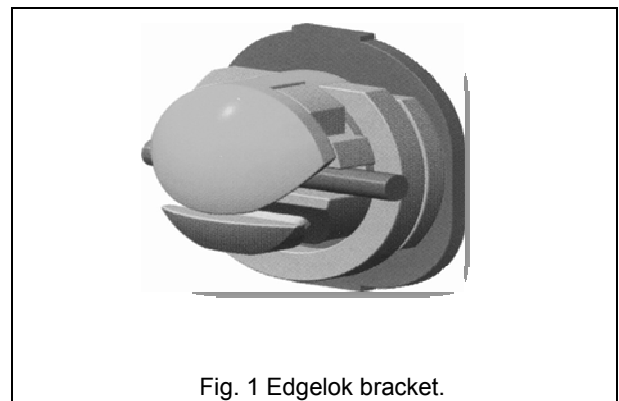


Fig. 1 Edgelok bracket.

Hanson in 1999 described various clinical uses of the SPEED appliance. The auxiliary tubes allow attachment of elastic hooks from either the mesial or distal. He said that it is possible to accomplish various objectives simultaneously like applying labial root torque to the canines while intruding the incisors.²⁸



Fig. 2 SPEED bracket.

MOBIL LOCK BRACKETS

The passive self-ligating designs were brought to the market in early 1980's. These 2 new self-ligating designs were invented by Rolf Foerster consisted of an edgewise model and a self-ligating Begg bracket.

The edgewise version was based on a design movable arch wire hook. It consisted of semi circular disk of variable thickness which could be rotated to entrap the arch wire with arch wire of adequately large dimensions. The disk could be rotated there by locking the arch wire.¹³ The Begg version featured a rotating cylinder with a protruding tab. The cylinder could be rotated to permit insertion of arch wire and rotated back to its original position to entrap the arch wire.

Both of these passive designs could not gain wide spread clinical acceptance.

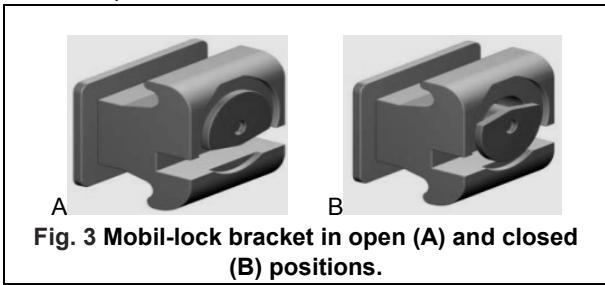


Fig. 3 Mobil-lock bracket in open (A) and closed (B) positions.

ACTIVA™:

In 1986 Activa bracket was brought into the market by “A” Company of Ormco Corporation. It is a passive self-ligating bracket featured a circular door which rotates around cylindrical bracket body permitting insertion and removal of arch wire. Once closed, the rigid outer wall of the movable arm converted the arch wire slot into a passive arch wire tube. The inner curvature of circular door increased the effective slot depth with small-diameter wires, diminishing labiolingual alignment with such wires. The decreased inter bracket distance and absence of tie wings are the limitations of Activa bracket design.²⁹ According to Griffics JM et al (1993), the advantages and disadvantages are as follows.

Advantages of Activa brackets

1. Low friction between bracket and arch wire.
2. More certain full arch wire engagement.
3. Less chair side assistance.
4. A vertical slot for hooks and auxiliaries.
5. Smoother and more comfortable.
6. Easier oral hygiene.
7. Better esthetics.

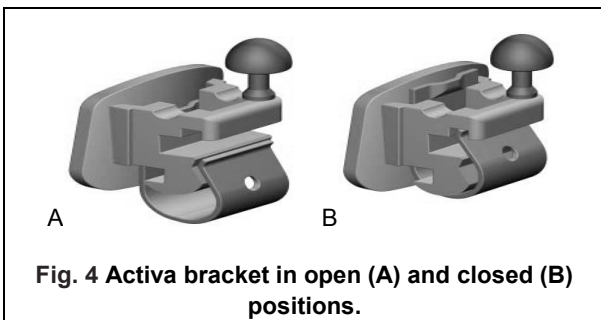


Fig. 4 Activa bracket in open (A) and closed (B) positions.

Disadvantages of Activa brackets

1. Higher bond failure rate.
2. Less convenient with elastomeric chain.
3. Unfamiliarity.
4. Harder to hold and seat when bonding.
5. Partial slot engagement not possible.
6. Breakage of arch wire retaining clips.
7. Low friction increases wire displacement.

TIME™

In 1996 another self-ligating bracket was introduced, the ‘Time’ bracket by ‘Adenta’ featured a rigid door pivoted on a small mount thus preventing arch wire insertion or removal. These attachments open slot by moving rigid door towards the gingiva and close slot by moving towards the occlusal side.³⁰ Although these resemble the SPEED design its rigid door did not permit active interaction with arch wire. The success of this passive design remains in question.



S Fig.5: Time bracket

DAMON SL1™

In 1996 the 1st of several Damon brackets was introduced, which is a trade mark of Ormco corp. It featured a rigid slide, which was wrapped around the bracket body could be moved to permit arch wire insertion and returns to its original position to entrap the arch wire. The Damon 1 was unique and popularized due to utilization of tie wings in self-ligating designs. These brackets were a definite step forward but had two significant problems, the slides sometimes opened inadvertently due to the play of the slide round the exterior of the bracket and they were prone to breakage due to work-hardening on the angles of the slide during manufacture. This design went several variations and replaced by Damon 2 design.^{31,32}

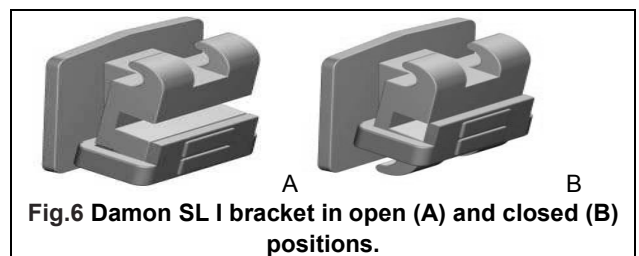


Fig.6 Damon SL I bracket in open (A) and closed (B) positions.

TWIN LOCK™

At the same time with the introduction of Damon 1, J. Wildman who invented the Edgelok bracket invented another self-ligating model called the Twin Lock appliance in 1998. It featured a flat rectangular passive slide tied between the tie wings and could occupy open or closed position. Notable to this design was very deep arch wire slot. One year after its introduction, the TwinLock bracket was modified slightly and introduced as Damon SL 2 bracket.¹

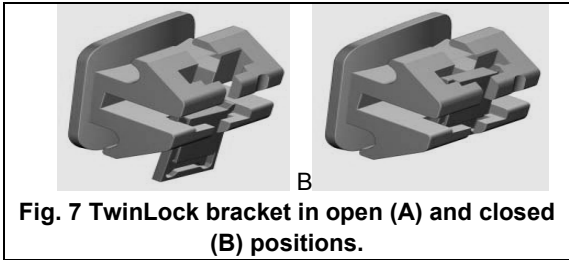


Fig. 7 TwinLock bracket in open (A) and closed (B) positions.

DAMON™ 2

In 2000, A passive Damon 2 self-ligating bracket was introduced, which design was very similar to that of Twin Lock design. Like the Twin Lock design, it featured a flat rectangular slide which is mounted between its tie wings.¹ the rigid slide could be moved up and down thus permits arch wire insertion and removal. This design was also replaced by Damon 3.



Fig. 8 DAMON 2 bracket

INOVIATION™

In 2000 GAC introduced a self-ligating bracket design which resembles G. Hanson's SPEED design, called In-Ovation bracket. It featured a curved flexible clip which could occupy a slot open or closed position. Like the Damon bracket, emphasis was given on incorporation of tie wings which could accommodate ligature ties. This resulted in a rather bulky design which later eventually reduced in size and turned into In-Ovation R brackets.^{1,13}

In 2002, smaller brackets for the anterior teeth became available, In-Ovation R (referring to the reduced bracket width) and this narrower width bracket design was effective in terms of greater interbracket span. The bracket subsequently became known as System R. They are a successful design, but some relatively minor disadvantages in bracket handling were initially apparent. 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, lacebacks, underties, and elastomerics placed behind the arch wire are competing for space with the bracket clip.¹³ The recently released Quick brackets (Forestadent Bernhard Foerster GmbH) 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 bracket.¹³

Fig.

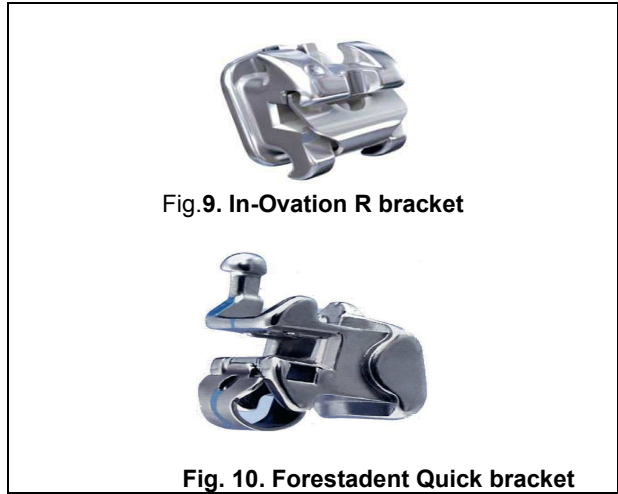


Fig.9. In-Ovation R bracket

Fig. 10. Forestadent Quick bracket

SMART CLIP™

Smart clip is a passive self-ligating bracket introduced in 2004, which is a trade mark of 3M Unitek Company. This bracket is Similar in design of Boyd and Brusse's bracket. This design featured two Nickel Titanium C-shaped clips on either side of bracket slot to retain the wire. The pressure required to insert or remove an arch wire is therefore not applied directly to a clip or slide but to the arch wire, which in turn applies the force to deflect the clips and thus permit arch wire insertion or removal.¹³

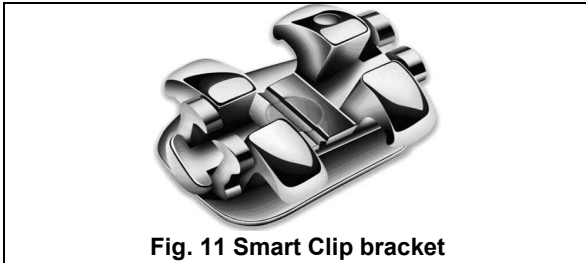


Fig. 11 Smart Clip bracket

OYSTER™ AND OPAL™ BRACKETS:

Oyster (2001), Opal (2004) are passive self-ligating brackets entirely made of plastic resin and featured a hinged cap which rotates open for arch wire insertion or removal. Good results can certainly be achieved with these brackets, but, as with all resin brackets, rigidity, robustness, and longevity are a challenge. Their success is questionable but they are still commercially available.³³

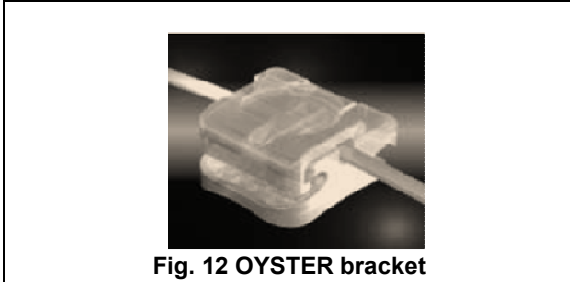


Fig. 12 OYSTER bracket

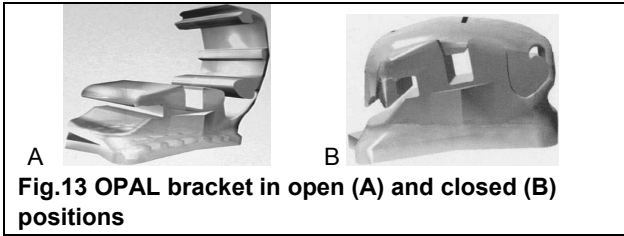


Fig.13 OPAL bracket in open (A) and closed (B) positions

DAMON™ 3, DAMON 3 MX AND DAMON Q BRACKETS

Plastic also made its way into Damon brackets. The Damon 3 self-ligating bracket introduced in 2004 features a metal arch wire slot and rectangular slide housed in a plastic shell. This plastic shell forms bracket base and tie wings. The rectangular slide functions same as in previous Damon models.

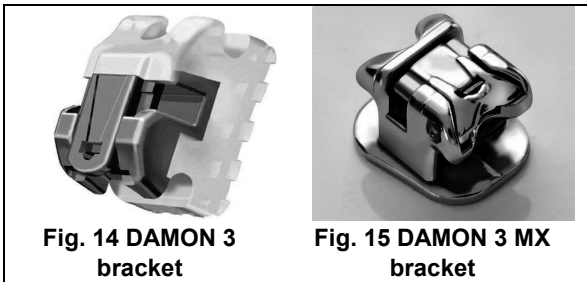


Fig. 14 DAMON 3 bracket

Fig. 15 DAMON 3 MX bracket

Damon 3 and Damon 3 MX brackets 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 esthetic. However, early production Damon 3 brackets suffered three significant problems: a high rate of bond failure, separation of metal from reinforced resin components, and fractured tie wings. The recently launched all metal Damon 3 MX and Damon Q brackets have clearly benefited from manufacturing and clinical experience with previous Damon brackets.¹³



Fig. 16 DAMON-Q bracket

VICTORY SERIES™ BRACKETS

The Victory Series™ Active Self-Ligating Bracket has a robust ligating mechanism that is designed for reliability of use and ease of operation. The full slot-width size door maximizes available rotational control capability. You can

also add optional APC™ II Adhesive coating to your Victory Series Active Self-Ligation System for reduced bonding steps and convenience. **Rounded slot edges** **Rounded slot edges** designed to reduce archwire binding. **Doors can be easily opened and closed** by using either the door U-notch or the gingival tab. Vertical groove under the door allows for easy opening from the U-notch.³⁴



Fig. 17 Victory Series™ bracket

EMPOWER BRACKETS

Empower which is a trade mark of American Orthodontics is the first to offer the versatility of both interactive and passive bracket designs in one unified system with coordinated in/out. Empower 2 metal brackets give you the choice of a fully interactive, fully passive, or combination Dual Activation™ system. These brackets provide self ligating benefits in a comfortable, low profile design.

Empower Clear self ligating brackets (American Orthodontics, Sheboygan, Wis) consists of ceramic bracket body and rhodium-coated clip deliver patient-pleasing aesthetics. Beauty and performance come together in Empower Clear brackets. This fully interactive aesthetic bracket gives the versatility and ease of self ligation, while giving the patients the beautiful smile they deserve both during and after treatment.³⁵

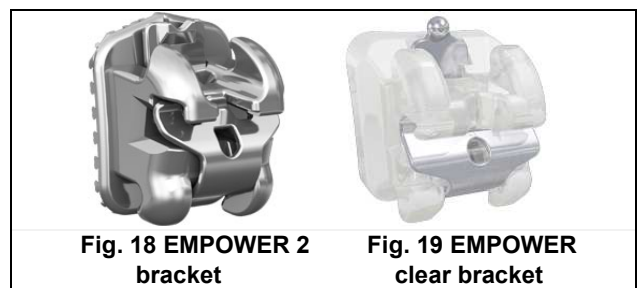


Fig. 18 EMPOWER 2 bracket

Fig. 19 EMPOWER clear bracket

SELF-LIGATING LINGUAL BRACKETS

The use of self-ligating brackets in lingual orthodontics was first presented by Neumann and Holtgrave, who suggested the use of SPEED (Strite Industries Ltd) self-ligating labial brackets for application in the lingual technique. The lingual technique presents particular difficulties when compared with the labial technique. Self-ligating brackets have important benefits that can overcome those difficulties, improve the performance of the lingual

appliance, and contribute to the efficiency of lingual orthodontic treatment.³⁶

1. Philippe 2D self-ligating lingual brackets (Forestadent Bernhard Foerster GmbH, **Fig-26**), providing 2-dimensional control, were suggested for the correction of simple malocclusions, such as minor crowding or spacing with the lingual technique. These brackets have no slot; they include small wings welded to the brackets base. The wings are used to secure the arch wire to the brackets base. The wings are closed, or pushed against the base of the brackets with Weingart utility pliers to hold the arch wire, and can be opened for arch wire replacement, using a thin spatula placed between the wings and the base of the bracket.³⁷

These brackets are comfortable to the patient as they have low profile. Four types of Philippe brackets are available: a standard medium twin, a narrow single wing bracket for lower incisors, a large twin, and a three-wing bracket for attachment of intermaxillary elastics. Philippe self-ligating brackets can be placed directly intraorally or prepared for indirect bonding on the malocclusion model. The main advantage of the Philippe brackets is their low profile and their comfort to the patients. They are suitable for simple cases that do not require 3-dimensional control since they have no slot.³⁸

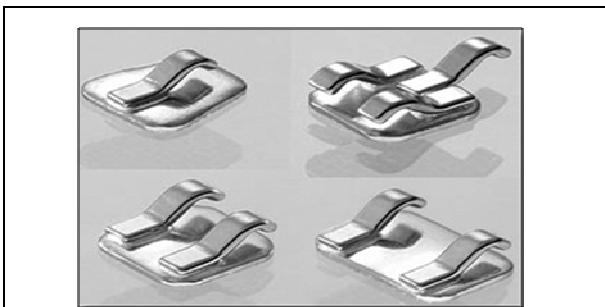


Fig. 26: Philippe 2D self-ligating lingual brackets. Four types of brackets are available: a standard medium twin (regularly used for the lingual technique), a narrow single wing bracket for lower incisors, a large twin, and a three-wing bracket for attachment of intermaxillary elastic. (Taken from Semin Orthod 2008;14:64-72.)

2.The Forestadent 3D Torque-Lingual self-ligating brackets have the similar flat design as the Philippe 2D self-ligating brackets, but have a vertical slot for 3-dimensional control. The vertical opening of the slot provides fast and easy arch wire insertion (**Fig-27**). The arch wire is used like a ribbon-arch, with the widest edge of the wire lying against the tooth surface; therefore the buccolingual slot dimension is smaller than the occlusogingivally slot dimension and the bracket is relatively flat, with a low profile. The arch wire is secured in the slot by small wings that can be pushed or opened like the wings of the Philippe 2D self-ligating lingual brackets. By pushing the wings against the bracket's base, and over the arch wire with Weingart utility pliers, the arch

wire is secured in the slot. A thin spatula placed between the wings and the base of the bracket is used for opening the bracket for arch wire replacement. The brackets are designed with 45° of torque for all the upper and lower incisors, and with 0° of torque for all the bicuspid and molars.³⁹

3. The Adenta Evolution lingual bracket (Adenta GmbH, **Fig-28**) is designed as a one piece bracket with a clip that opens at the incisal edge and allows insertion of the arch wire from the occlusal direction. The clip can serve also as a bite plate, and consequently presses the arch wire further into the slot when biting.^{36,40}

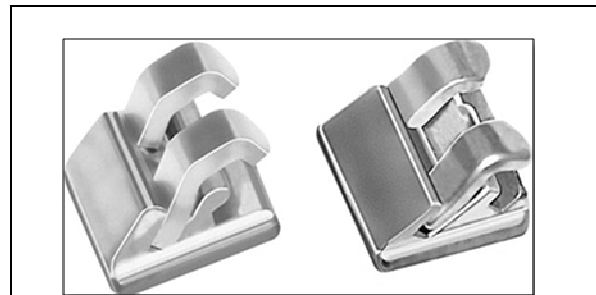


Fig. 27: The Forestadent 3D Torque-Lingual selfligating brackets have the similar design as the Philippe 2D self-ligating brackets, but have a vertical slot for fast and easy arch wire insertion (Taken from Semin Orthod 2008;14:64-72.)



Fig.28: Evolution Brackets (source: http://www.adentause.com/article_id-16&clang=0)

Dr. Hatto Loidl, an orthodontist from Berlin, Germany and Mr. Claus Schendell, owner and engineer of Adenta GmbH, together designed a new self-ligating lingual bracket and modified HIRO system called the Evolution sit bracket system. Eliminating the old lingual systems disadvantages and producing a lingual technique with individual transfer caps, that can be fabricated easily with-out the use of costly equipment using Smart Jig technology.³⁶

In a study comparing the 3D Forestadent and Adenta Evolution brackets it was found that both brackets had some limitations in handling. Both 3D Forestadent and Adenta Evolution brackets are wide mesiodistally, and this caused

difficulties in handling due to reduced interbracket distance.⁴¹

4. In-Ovation-L (GAC International) lingual brackets are twin, horizontal slot brackets, with an interactive clip with very easy effortless opening (**Fig-29**). The bracket wings and clips have a very low profile and the base of the incisor brackets is bent to fit the anatomy of the palatal surface of the incisors. Low profile brackets with minimal bucco-lingual width allow a larger arch wire perimeter and an increased interbracket distance; the latter design of brackets therefore has advantages in lingual orthodontics. The low profile of the brackets contributes also for greater patient comfort.^{36,38}

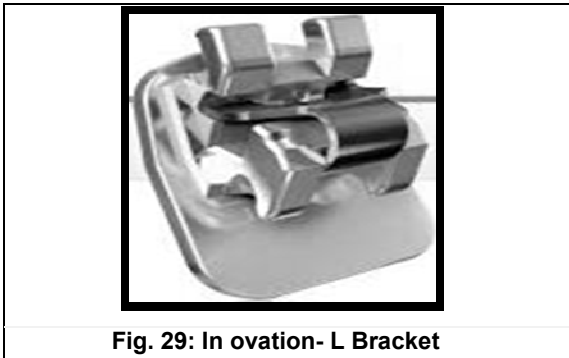


Fig. 29: In ovation- L Bracket

5. Phantom (Gestenco International) is a polyceramic self-ligating bracket (**Fig-30**). These brackets are bonded directly in the mouth after preparation of the lingual surfaces of the teeth by reshaping and filling all irregularities with flowable composite.³⁸

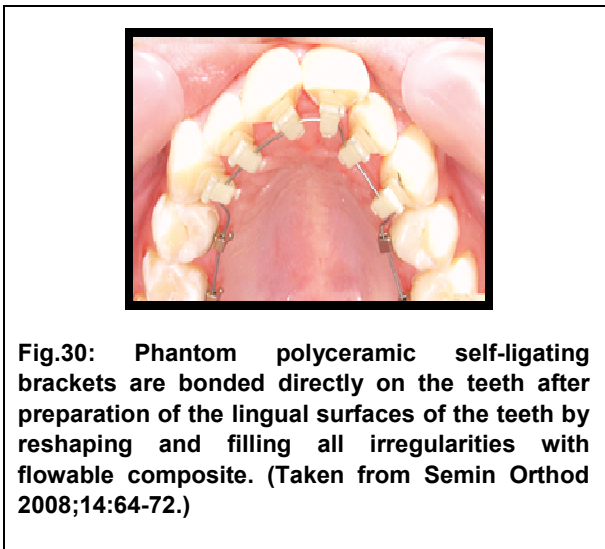


Fig.30: Phantom polyceramic self-ligating brackets are bonded directly on the teeth after preparation of the lingual surfaces of the teeth by reshaping and filling all irregularities with flowable composite. (Taken from Semin Orthod 2008;14:64-72.)

PROPERTIES OF AN IDEAL LIGATION SYSTEM

The concept that brackets are ligated via tie-wings is so prevalent that it is worthwhile considering a list of ideal properties of any ligation system. This exercise puts in perspective any assessment of the benefits and difficulties with current self-ligating systems. Ligation should:¹

- Be secure and robust;
- Ensure full bracket engagement of the arch wire;
- Exhibit low friction between bracket and arch wire;
- Be quick and easy to use;
- Permit high friction when desired;
- Permit easy attachment of elastic chain;
- Assist good oral hygiene;
- Be comfortable for the patient.

Advantages of self-ligating brackets

These advantages apply in principle to all self-ligating brackets, although the different makes vary in their ability to deliver these advantages consistently in practice:

1. More certain full arch wire engagement
2. Low friction between bracket and arch wire;
3. Less chair side assistance;
4. Faster arch wire removal and ligation.

1. Secure full arch wire engagement:

Full engagement is a feature of self-ligation because a clip/slide is either full shut or it is not. Unintentional partial engagement is not possible. There is no problem of decay of the ligature as with elastic ligatures. However, security of ligation will depend on the clip/slide being robust and not inadvertently opening.

2. Low friction:

Very low friction with self-ligating brackets has been clearly demonstrated and quantified in work by various authors,^{21,42,43,44} for both Activa and Speed brackets, and Edgelok. The friction is dramatically lower than for elastomeric rings with conventional brackets and seems to be an inherent characteristic of self-ligating brackets. Thomas .et.al²⁹ confirmed extremely low friction with Damon brackets compared to both conventional pre-adjusted and also Tip-Edge brackets. Pizzoni et al.²⁶ have reported that Damon brackets showed lower friction than Speed which in turn had less friction than conventional brackets stating that: in the case of rectangular wires, the Damon bracket was significantly better than any of the other brackets and should be preferred if sliding mechanics is the technique of choice.

The combination of very low friction and very secure full arch wire engagement in an edgewise-type slot is currently only possible with self-ligating brackets (or with molar tubes) and is likely to be the most advantageous feature of such brackets. It has therefore been proposed that this combination enables a tooth to slide easily along an arch wire with lower and more predictable net forces and yet under complete control, with almost none of the undesirable rotation of the tooth resulting from a deformable mode of ligation such as an elastomeric.¹⁴

Friction in vivo and with active wires

It is, yet, difficult to be certain how accurately any laboratory simulation of friction reproduces the true in vivo situations. A study by Loftus et al.⁴⁵ found that in an

experiment with a simulated periodontal ligament and with slight tip and rotation of the brackets, the friction with Damon SL was not significantly less than with conventionally ligated brackets. Read-Ward et al⁴⁶ reported that the reduction in friction with self-ligation is much less when the wire is active, but this study also showed the considerable methodological problems in measuring friction with active wires, the standard deviation of repeated measurements being very high. Other authors found friction with self-ligating brackets to still be substantially lower even at high values of active torque. A study by Thorstenson and Kusy,⁴⁷ examined the effects of varying active tip (angulations) on the resistance to sliding. They found that angulations beyond the angle at which the arch wire first contacts the diagonally opposite corners of the bracket slot causes a similar rise in the resistance to sliding of both self-ligated (Damon SL) and conventional brackets. Self-ligation provides very significant reduction in friction in all dimensions of tooth movement.

Anchorage consequences of low friction and secure full arch wire engagement:

- i. With low friction, the net tooth-moving forces are more predictably low and the reciprocal forces correspondingly smaller. Although the evidence shows that the relationship between force level and tooth movement is complex, it does support the idea that lower forces per unit root area lead to more anchorage.
- ii. Lower net forces deflect arch wires less and, therefore, facilitate release of binding forces between wire and bracket, enhancing sliding of brackets along a wire.
- iii. Individual teeth -for example, canines can be retracted separately along an arch wire and thus potentially reduce the overall anchorage demands by reduction of the root area of teeth to be moved at any one time, but with none of the potential disadvantages of other methods of separate canine retraction, e.g., loss of rotational control.⁷

Alignment of severely irregular teeth

The other situation in which the combination of low friction and secure full engagement is advantageous is alignment of very irregular teeth and the resolution of severe rotations, where the capacity of the wire to slide through the brackets of the rotated and adjacent teeth significantly facilitates alignment. This relationship between friction and derotation has been described and quantified by Koenig and Burstone,⁴⁸ and the potential adverse forces shown to be very large. Low friction, therefore, permits rapid alignment and more certain space closure, whilst the secure bracket engagement permits full engagement with severely displaced teeth and full control, whilst sliding teeth along an arch wire.

Less chair side assistance and faster arch wire removal and ligation

The original motive when developing the earlier self-ligating brackets was to speed the process of ligation. For

example a paper by Maijer and Smith⁴⁹ demonstrated a four-fold reduction in ligation time with Speed brackets compared to wire ligation of conventional brackets. Shivapuja and Berger²¹ have shown similar results but also that the 'speed advantages compared to elastomeric ligation are less dramatic (approximately 1 minute per set of arch wires). Voudouris⁴⁰ has also reported a fourfold reduction in arch wire removal and ligation time with prototype Interact twin brackets which lead to the commercially available In-Ovation brackets. A study by Harradine found statistically significant, but clinically every modest savings in ligation /re- ligation time with Damon SL - an average of 24 seconds per arch wire removal and replacement. It should, however, be remembered that arch wire ligation' using self-ligating brackets does not require a chair side assistant to speed the process. A study of treatment efficiency by Harradine¹ found the following:

- I. A very modest average time saving from a reduction in arch wire placement/removal of 24 seconds per arch,
- II. A mean reduction of 4 months in active treatment time from 23.5 to 19.4 months,
- III. A mean reduction of four visits during active treatment from 16 to 12, and the same average reduction in Peer Assessment Rating scores for matched cases.

COMPARISON OF SELF-LIGATED AND CONVENTIONALLY LIGATED BRACKETS

The important characteristics and differences between the two types of brackets are summarized and given in table II.¹²

CONCLUSION

Every self-ligating bracket, whether active or passive, uses the movable fourth wall of the bracket to convert the slot into a tube. Numerous studies have demonstrated a dramatic decrease in friction for self-ligating brackets, compared to conventional bracket designs. Such a reduction in friction can help shorten overall treatment time, especially in extraction cases where tooth translation is achieved by sliding mechanics. Several authors have indicated that the use of self-ligating brackets can reduce treatment time by about four months and save significant chair time in changing arch wires. These factors add up to a considerable cost saving.

As more orthodontic practices embrace the concept of self-ligation, it is becoming apparent that stainless steel and elastomeric ligatures will eventually be as outdated as full banding is today. Considering the advantages of self-ligating brackets for the clinician, staff, and patient, they may well become the "conventional" appliance systems of the 21st century.

Table.2.DIFFERENCES BETWEEN SELF-LIGATED AND CONVENTIONALLY LIGATED BRACKETS¹²

CHARACTERSTIC	Self-Ligated	Conventionally Ligated
<i>Esthetics</i>	Some designs permit significant miniaturization	Limited miniaturization
<i>Force Level</i>	Permits use of lighter forces	Requires heavier force levels
<i>Force Delivery</i>	Light initial force	High initial force
<i>Friction</i>	Predictable, very low	Stainless steel: High Elastomeric: Very high
<i>Infection Control</i>	Significantly reduced risk of Percutaneous injury	Increased risk of Percutaneous injury
<i>Instrumentation</i>	Fewer instruments required during arch wire changes	Many instruments required during arch wire changes
<i>Ligation</i>	Movable, integral component creates outer fourth wall	Stainless steel or elastomeric ligatures
<i>Ligation Stability</i>	Retains original form throughout treatment	Loses initial shape and tightness
<i>Office Visits</i>	Shorter, less frequent visits	Longer, more frequent visits
<i>Oral Hygiene</i>	Wingless designs easy to clean	Difficult to clean—food traps
<i>Patient Comfort</i>	Only slight discomfort with wire changes	Teeth usually sore after ligation
<i>Sliding Mechanics</i>	Ideally suited for efficient tooth translation	Slow due to binding of arch wire
<i>Treatment Time</i>	Overall treatment reduced by about four months	Longer, especially in extraction cases

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