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Self Ligating Brackets-A Comprehensive Review

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ABSTRACT

Self-ligating brackets (SLBs) are orthodontic appliances that eliminate the need for elastic or metal ligatures to hold the archwire in place. They use a built-in clip or sliding mechanism, reducing friction and enabling more efficient tooth movement. SLBs offer advantages such as shorter treatment duration, fewer appointments, improved oral hygiene and increased patient comfort. Research suggests that these brackets may reduce overall treatment forces, potentially leading to less discomfort. Despite higher initial costs, their benefits make them a popular choice in modern orthodontics for effective and aesthetic treatment.

Keywords: Self ligating brackets; low-friction; active brackets; passive brackets; ligature-less.

1. INTRODUCTION

Since its emergence in the early 20th century, the field of orthodontics has undergone continuous transformation with advancements in appliance design, biomechanics and treatment paradigms which has significantly contributed to a deeper comprehension of the principles governing orthodontic tooth movement. Since then, numerous orthodontic companies have introduced their own bracket systems each with distinct prescriptions, treatment philosophies and mechanics.[1] However, they all have one common feature, ie, the ligatures are required to secure arch wires in the bracket slot by looping around the tie wings.[1] Conventional orthodontic treatment relies on elastomeric or metal ligatures to fasten the archwire within the bracket slot regulating the forces applied to the teeth.[2] The use of ligatures was replaced with the introduction of the ligature-less self-ligating bracket system.

A self-ligating bracket (SLB) is defined as a bracket that utilizes a permanently installed, movable component to entrap the archwire without the need for additional ligature.[2] These bracket systems represent a major advancement in modern orthodontics, moving away from conventional brackets that require ligatures to secure the archwire. This distinctive approach enables precise friction control during tooth movement, improving both treatment efficiency and overall results.[3] These innovative systems have attracted significant interest and recognition within the orthodontic field because of their unique design, functionality and possible clinical benefits.

A safe passive or active ligation system ensures secure engagement of all brackets while minimizing the friction between the brackets and arch wire. This reduction in friction facilitates faster tooth movement while maintaining precise control over tooth positioning through appropriately sized brackets.[4] Additionally, the system decreases chairside time and enables quicker archwire ligation and removal. These advancements have the potential to significantly shorten overall treatment duration and reduce the necessity for anchorage especially in cases that require substantial tooth movement.[5]

2. PHILOSOPHY OF SELF-LIGATING BRACKET SYSTEM

The proponents of this system have stated that light forces play a crucial role in self-ligation. Low-force, low-friction systems enable teeth to move naturally into their proper position without overpowering the surrounding muscles or harming the periodontal tissues.[6] Since the forces exerted by small-diameter, advanced archwires are minimal, they do not completely block the periodontal blood supply, preventing ischemia. In contrast, excessive force on teeth can lead to hyalinization of the periodontal ligament. Self-ligating brackets generate just enough force to cause tooth movement while preserving vascular supply, making the process more efficient and biologically compatible. The final tooth alignment in self-ligating bracket systems is achieved through the equilibrium between oral musculature and periodontal tissues rather than relying on strong orthodontic forces. Additionally, the passive self-ligating bracket design allows teeth to move along the path of least resistance. Hence, when the bracket's slide locking plate is closed, it functions like a tube, allowing the flexible nickel-titanium archwire to glide smoothly.[6] By significantly reducing friction, passive self-ligating brackets enable low-force archwires to work at their optimal potential, promoting a more natural and effective tooth movement process. Furthermore, tooth movement is more efficient when each tooth can shift independently. While still connected through the archwire, passive self-ligating brackets provide greater freedom for teeth to settle into their natural position since the archwire is not tightly secured within the bracket slot.

3. CLASSIFICATION OF SELF-LIGATING BRACKETS

Self-ligating brackets are categorized into two types: active and passive brackets based on how they interact with the archwire.[1] Active brackets feature a spring clip that extends from the labial or buccal side, applying pressure on the archwire. This force ensures secure engagement and active seating of the archwire such as the In-Ovation (GAC International, Bohemia, NY, USA), SPEED (Strite Industries, Cambridge, Ontario, Canada) and Time brackets (Adenta, Gilching/Munich, Germany).[1] In contrast, passive brackets utilize a rigid door or latch to hold the archwire in place without applying pressure.[1] This design provides more space for the archwire within the bracket slot such as Damon (Ormco/"A" Company), SmartClip™ (3M Unitek, USA) and Oyster ESL brackets (Gestenco International, Gothenburg, Sweden).

4. HISTORY AND DEVELOPMENT OF SELF-LIGATING BRACKETS

Russell Lock edgewise attachment

In 1935, the first self ligating bracket, the Russell lock attachment was developed by Dr. Jacob Stolzenberg. This bracket has a threaded, circular aperture on its surface that is fitted with a flat-head screw.[7]

Edgelok brackets

In 1972, Dr. Jim Wildman introduced the first modern passive self ligating bracket, the Edgelok bracket, which had a round body and a rigid labial sliding cap.[8] To insert the archwire, the slide needed to be repositioned occlusally using a specialized opening tool.

Mobil-Lock brackets

In 1974, Dr. Franz Sander designed the Mobil-Lock bracket, which required a specialized tool to rotate the semi-circular labial disk for opening or closing.[2] The archwire was securely housed within a tube formed by the outer wall of the bracket slot.

Speed system

In the late 1970s, Hanson introduced an innovative, robust, self-ligating mechanism which is a ligature-free design that securely holds the curved wire within its designated aperture while maintaining effective control through a spring-loaded, self-adjusting mechanism.[9]

Speed appliance design

A Speed attachment consists of four components: the bracket body, a permanently affixed spring clip, the in-out adaptor and the foil mesh bonding base. While they may appear identical, each Speed attachment is uniquely designed for a specific tooth.[9]

The bracket body

The speed appliance features a sleek, single-bracket design. Its precisely engineered bracket body includes multiple openings for different components, such as a pre-torqued archwire slot, an auxiliary slot and a spring retention slot.[10] The archwire slot available in either 0.018 x 0.025 inches or 0.022 x 0.028 inches accommodates archwires of any shape or size.

The spring clip

The Speed bracket features a roll-shaped, flexible, vertically opening and closing spring clip that simplifies archwire removal and insertion.

The in-out adaptor

This exceptional feature enables the creation of an exceptionally smooth arch shape through a gradual, ramp-like effect of the in-out adaptors. The newly enhanced and more durable design of each adaptor has allowed manufacturers to lessen the size of their appliances while significantly increasing bond strength by over 300%.[2]

The mesh pad

Each Speed fastener features a bonding pad composed of foil mesh with intricate asymmetrical curves. These curves along with the smaller size of each mesh pad ensure good adaptability between the tooth and bracket.

Activa Brackets

The Activa bracket slot had a concave labial surface due to its spinning slide (manufactured by “A” Company, San Diego, CA). This design increased the effective slot depth, reducing labiolingual alignment when using wires of smaller diameters. Additionally, securing the slide at the mesial and distal ends of the slot made the bracket wider than usual, which consequently shortened the inter bracket span and limited its advantages.[11]

Self-ligating interactive bracket system

A self-ligating interactive bracket system utilizes a clip mechanism that allows for easy opening and closing while changing the arch wires. In the initial phase of treatment, it applies minimal force and friction in a passive manner. However, active torque and rotational control remain consistent throughout the entire treatment process. The system features limited points of contact inside and outside the arch, enabling precise adjustments in all three spatial dimensions for optimal finishing.[12]

Time 2 (American Orthodontics)

The Time 2 bracket's base and body are produced as a single unit using the metal injection molding (MIM) process, creating an active system. By inserting a designated tool on the labial side, the bracket can be opened, allowing the mechanism to hinge in a gingival direction. A specialized instrument is then used to lock the bracket securely in place.[13]

Time 3 (American Orthodontics)

Compared to the Time 2 bracket, the Time 3 bracket has a more compact design. Both the base and body of the bracket are manufactured using MIM technology.[13]

Damon Appliance System

The Damon system, developed in the mid-1990s, featured a sliding mechanism that covered the labial surface of the bracket. This system operates on the principle that a minimum force is required to initiate tooth movement. The Damon self-ligating bracket (SLB) was specifically designed to meet several key criteria, including adherence to Andrews' Straight-Wire Appliance concept, a twin bracket configuration, a fully enclosed slide forming a tube, a passive slide positioned on the bracket’s outer surface and an opening mechanism that functions downward in both dental arches. The Damon appliance is available with either a 0.022-inch or 0.018-inch slot. The Damon tubes are manufactured using metal injection molding, which enables the precise creation of small components such as those that ensure the slide moves freely and the archwire slot maintains tight tolerances.

Bracket Design

Initially introduced as the Damon SL bracket, the design has evolved into its current form, featuring a passive self-ligating system rather than an active one. It includes standard tie wings and a gate mechanism that opens to expose the slot, utilizing a secure locking system to keep it open or closed. Over time, the bracket has been refined to have a slimmer profile, softer and rounder edges, enhancing patient comfort. Additionally, the D3 MX bracket incorporates a vertical auxiliary slot.[14] The Damon standard prescription is advised for all molars and premolars, as well as incisors and canines that are properly aligned, including labially inclined canines. Damon 2 brackets, developed by Ormco Corporation, were designed to improve upon the shortcomings of Damon SL. They retained the U-shaped spring and vertical sliding mechanism for opening and closing but featured a concealed slide hidden beneath the tie-wings.[14] Damon 3 brackets, also from Ormco Corporation, introduced a repositioned and differently operated holding spring, ensuring a smoother and more dependable opening and closing function.[14] The Damon Q and Q2 brackets represent significant advancements in orthodontic technology. These brackets are part of an orthodontic system designed to enhance tooth alignment and improve treatment effectiveness. Their standout feature is the self-ligating mechanism, which securely holds the archwire in place without requiring extra elastic or metal ligatures. This innovative design helps to minimize friction, potentially allowing for smoother and more comfortable tooth movement. Built upon insights gained from earlier models and clinical practice these brackets incorporate enhancements that further optimize their performance.[14]

Twin Lock Bracket

The Twin Lock bracket, introduced in 1998, featured a flat, rectangular slide that is pushed occlusally into the empty space using a large scaler, securing it between the tie-wings of the edgewise twin section. When finger pressure is applied, the device moves gingivally, holding the archwire in a neutral position.[2]

Oyster Self-Ligating Bracket

Translucent self-ligating brackets (SLBs) were introduced to the market in 2003 as a more aesthetically appealing alternative to conventional self-ligating metal brackets. These brackets are made from a composite polymer reinforced with fiberglass, ensuring durability. The Oyster ESL consists of 70% polycarbonate (PC) and 30% polyethylene terephthalate (PET).[15] Designed as a standard or Roth prescription edgewise bracket, it features a 018’’ or 022’’ slot.

In-Ovation R (GAC)

The In-Ovation brackets[16] were launched in 2000 by GAC Company. The In-Ovation R featured an electronic bracket with a design reminiscent of the classic twin style, built on a precisely defined and sculpted bracket body.

Opal Bracket

It is a type of passive bracket made from a translucent fiber-reinforced composite polymer. Constructed as a single seamless piece, it features a built-in mechanism in the lid that enables self-ligation.[17]

Opal M (Ultradent)

The MIM method is used to create the passive Opal M bracket.[17]

SmartClip Self-Ligating Brackets

These were launched by 3M Unitek in 2005. These brackets follow the McLaughlin Bennett Trevisi (MBT) prescription and feature a twin-bracket design. They secure the archwire using a nickel-titanium clip, which is highly resilient due to the properties of the nickel-titanium alloy allowing it to return to its original shape even after bending or twisting.[2]

Quick 2 (Forestadent)

The Quick bracket from Forestadent is a self-ligating bracket designed for efficient operation. It is manufactured as a single unit using Metal Injection Molding (MIM) and sintering technology. The clip's elasticity is achieved through a chromium-molybdenum alloy.[18,19]

Clarity SL (3M Unitek)

The ceramic body of the Clarity SL bracket makes it a passive system. The frictional properties of the ceramic base are enhanced by a metal groove.[20]

Vision LP (American Orthodontics)

The Vision Low Profile (LP) is a versatile system featuring tie wings. Its frame and base are manufactured using MIM sintering.[2]

Discovery SL (Dentaurum)

Designed with a passive approach, the Discovery SL bracket featured tie-wings and a curved base. Its base and body are manufactured using the MIM sintering method.[2]

5. SELF LIGATING LINGUAL BRACKETS

Philippe 2D (Forestadent Bernhard Forster GmbH)

The Philippe 2D brackets, [21] developed by Forestadent Bernhard Forster GmbH, are designed for the correction of mild malocclusions such as crowding or spacing using the lingual technique. These brackets provide two-dimensional control and do not include a conventional slot; instead, they feature small wings soldered to the base. Their low-profile design minimizes patient discomfort. There are four primary types of Philippe brackets: the medium twin, commonly used for lingual treatment; the large twin; the three-wing bracket, which allows for intermaxillary elastic connections and the narrow single-wing bracket specifically designed for lower incisors.

Forestadent 3D torque-lingual SLB

The Forestadent 3D Torque-Lingual SLB brackets[22] share similarities with the self-ligating Philippe 2D brackets but include a vertical slit that enables three-dimensional control. The vertical orientation of the slot simplifies archwire insertion. Additionally, the flat bracket design and the ribbon-like positioning of the archwire along the tooth surface contribute to its low profile. The buccolingual slot dimension is smaller than the occlusogingival slot size, enhancing control and efficiency in treatment.

In-Ovation - L (GAC International)

The Adenta Evolution lingual bracket features a clip design that opens at the incisal edge, allowing the archwire to be inserted from the occlusal side. When the patient bites down, the clip can function as a bite plate, helping to secure the archwire further into the slot. These brackets are placed indirectly using a customized laboratory HIRO system along with a specially designed “Smart Jig.”[210]

Phantom (Gestenco International)

These lingual brackets consist of a pair of horizontal slot brackets equipped with a clip that opens with a simple touch. They feature exceptionally thin wings and clips, while the incisor brackets have a curved base designed to fit the palatal surface of the teeth. Using low-profile brackets with a narrow buccolingual profile can help create additional space for the archwire and between brackets.[2]

6. CLINICAL TIPS WITH MANAGEMENT OF SELF LIGATING BRACKETS

1. Secure and robust ligation

Ensuring secure and complete engagement of the archwire optimizes the extended range of action provided by modern low-modulus wires and reduces the necessity of reestablishing control over teeth when full engagement is compromised during treatment. Once the wire is secured, it should remain reliably ligated to prevent unintended loosening. Wire ligatures offer strong retention, whereas elastic ligatures are more prone to disengagement. Additionally, elastic ligatures undergo considerable force degradation over time.[23]

2. Archwire engagement with self-ligating brackets

Instruments such as ligature tucker or Mitchel's trimmer can be used to hold the arch wire into the slot base. However, these apply pressure to only one side of the bracket and may not effectively secure the wire across the entire width of the slot.[1] Therefor ,Cool Tool (Damon) which looks similar to a torquing key and the R tool (GAC) which resembles a double ligature tucker can be used for engagement of wires enabling balanced pressure on both the sides of the bracket .[1] In cases of severely rotated teeth where one end of the bracket slot is too close to the adjacent tooth to allow instrument access for seating the wire, dental floss or a ligature wire can be looped over the archwire to assist in fully engaging the wire in that side. Besides this, Harradine et al in 2003, proposed an alternative technique for engaging significantly rotated or displaced teeth with self-ligating brackets .[23] He suggested closing the clip or slide first to convert the bracket into a temporary "molar tube" and then threading the aligning wire through the closed bracket before securing it in the remaining brackets.

3. Opening slides / clips

In-Ovation brackets are unlocked by pushing the tail of the clip in an occlusal direction from behind the bracket. It is crucial to avoid excess composite resin near this tail during bracket placement, as it can obstruct or completely prevent the clip from opening, especially in the lower arch where the tail is not visible from the operator's perspective. Time and Speed brackets can be opened using a probe or a sharp instrument like a Mitchell's trimmer by utilizing the hole in the clip. For Damon brackets, Kasso Damon pliers are highly effective and specifically designed for this purpose. These pliers are particularly recommended for first-time users, as they significantly simplify the process of opening the slides.

4. Longer intervals with appointments

Ensuring full and secure wire engagement in self-ligating brackets combined with the use of low modulus wires naturally supports extending the time between appointments. Hence, patient follow-ups can be scheduled at intervals of eight to ten weeks.[24]

5. Modification of treatment mechanics

The combination of minimal friction and complete secure bracket engagement may aid in the modifications in treatment mechanics as the treatment progresses.

6. Prevention of wire pokes

Low friction can contribute to increased wire displacement, especially in cases with highly irregular teeth. The reduced friction associated with self-ligating brackets allows aligning archwires to move more freely through the brackets, sometimes leading to protruding wire ends. To manage this issue, tie-backs with flexible wires can be used over extraction sites to minimize the effects of occlusal forces on unsupported wire segments. Another preventive measure is carefully bending the ends of flexible archwires. A significant advancement in this field is the Bendistal plier, introduced by Khouri in 1998, which allows for precise distal end bends in super-elastic wires without excessive manipulation.[1] This reduces potential discomfort and lowers the risk of dislodging a bonded molar tube. Additional solutions include crimp-on split tubes from manufacturers such as Unitek and Ormco. These small, pre-made devices can be easily attached to most wires without requiring custom fabrication. Although they are effective, they should not be placed on actively engaged sections of the archwire, as this could limit its functionality . Another approach involves selectively securing certain brackets to the archwire using elastomerics particularly in designs that incorporate a full conventional tie-wing assembly.

7. DEBONDING OF SELF-LIGATING BRACKETS

Debonding of self-ligating brackets can occur due to failure at the bracket-adhesive interface, cohesive failure of the adhesive, failure at the adhesive-enamel interface or a combination of these factors. In the Damon system, the most effective method for debonding self-ligating brackets is to apply pressure to two tie wings using a conventional debonding plier, allowing the bracket to detach smoothly from the adhesive. For 3M Unitek™ self-ligating bracket systems, including Clarity SL and SmartClip self ligating brackets, a specialized debonding tool has been designed.

1.Ultrasonic Debonding

The ultrasonic technique utilizes specially designed tips that are positioned at the bracket-adhesive interface to break down the adhesive layer bonding the bracket base to the enamel. This method significantly decreases the force needed for bracket removal compared to traditional techniques.[25] However, a major drawback is the extended debonding time, requiring approximately 30 to 60 seconds per bracket, whereas conventional methods take only 1 to 5 seconds.[26] Furthermore, ultrasonic tips wear down quickly and are expensive to replace. Consequently, this technique is not yet recommended for routine clinical practice.

2. Electrothermal debonding

Electrothermal debonding instruments are wireless, rechargeable tools designed to produce heat, which are then applied to orthodontic brackets. This heat is conducted through the bracket, softening the adhesive and allowing the bond between the bracket base and the resin to break.[27] This method enables quick and efficient bracket removal. However, a major concern is the high temperatures generated at the heated tip, which can potentially cause risks such as mucosal burns and pulpal damage**.**

3. Laser debonding

CO2 and YAG lasers can be used for debonding ceramic brackets.[28] The laser technique operates on a principle similar to the electrothermal method utilizing heat to soften the adhesive. Although still in the experimental phase, this approach provides greater accuracy in timing and heat distribution enabling better regulation of the heat transferred to the tooth.[29] However, a major drawback apart from the potential effects of thermal energy on the pulp is the high cost of the equipment.

Limitations

1. More expensive compared to conventional brackets.

2. The brackets have a high profile and appear bulky due to their complex mechanical structure.

3.The locking slide is designed to be flexible but may break compromising the self-ligating function.

8. CONCLUSION

Although introduced in the 1930s, the self ligating brackets have experienced a resurgence over the past three decades. They have emerged as a significant advancement in orthodontics, offering various benefits over conventional brackets, such as reduced treatment duration, minimized discomfort, improved periodontal health, enhanced torque control and more effective arch dimensional modifications. Additional benefits may involve better anchorage preservation, increased expansion, reduced forward inclination of front teeth and decreased necessity for extractions. Ultimately, the choice between self-ligating and conventional brackets should be based on individual patient needs, treatment goals and clinical experience.

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