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Self-ligation in orthodontics – A brief review

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Abstract: *The availability, use, choice, and quality brackets have increased very rapidly in recent years. The self-ligating bracket was introduced to create a "friction-free" environment with the belief that it will allow for better sliding mechanics; as the teeth move more rapidly, treatment time is decreased. Additionally, the self-ligating bracket is suggested to reduce chair side time, promote better oral hygiene and allow for better infection control. The basic premise of the self-ligating bracket is that the closing or opening mechanism of the bracket turns the bracket slot into the tube that passively or actively contains the wire. In the absence of wire or elastomeric ties presumably frictional resistance is dramatically reduced and tooth movement occurs at a greater velocity. This review article merely focus on history, types, properties, advantages and limitations of self-ligating bracket system.*

Key Word: *Self-ligating brackets (SLBs), Active clips, Passive slide, Smart clip, Lateral Expansion*

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I. Introduction:

The dawn of the 21st century in orthodontics has been accompanied by significant developments that affect our decision making in multiple facets of clinical practice. Self ligation is one of the most important advancements in orthodontic practice. The first self-ligating bracket, the Russell attachment was introduced by Stolzenberg in 1930.[1] Perhaps because of lack of promotion, it did not gain much popularity. Self-ligating brackets have made a major impact in orthodontics in the last ten years. It can be considered as a new revolution in orthodontic treatment and it can be argued that they are more than just a bracket system facilitating tooth movements that are difficult to achieve with conventional appliances. A better description is that they are ligature less brackets in that they do not use ligatures. Self-ligating brackets have an inbuilt metal labial attachment which can be opened and closed.[2]

For several decades these brackets had only minimal following. Various cases demonstrated rapid and successful treatment, but the majority of orthodontists were not sufficiently convinced to leave traditional ligation and many manufacturers remained unconvinced for significant financial investment in such technology. This was due to an innate conservatism, a misunderstanding of the advantages of self-ligation but also to deficiencies in the available brackets, which tended to prevent the use with ease and confidence. Those times have passed, modern manufacturing techniques and better design have produced a variety of robust, reliable, effective, and easy to use brackets.[3]

II. Definition and Classification

A self-ligating bracket is defined as "a bracket, which utilizes a permanently installed, moveable component to entrap the archwire".

Self-ligating bracket restrains the archwire within the slot by means of a slide or a clip that covers the slot.[4] Self-ligating brackets are intended to replace existing ligation methods with elastomeric and stainless steel ligatures to facilitate clinical efficiency.

SL brackets can be classified into those with the presence or absence of a spring clip:

Passive self ligation: They use a rigid moveable component to entrap the arch wire. Tooth movement with passive brackets is determined solely by the fit between bracket slot and the arch wire. However, an undersized wire can't touch the walls of the bracket slot. Passive brackets lack their ability to control tooth movements because of their total dependence on the fit between the arch wire and the bracket slot.

Examples are the Damon, Activa, Twin lock, SmartClip, BioQuick, ProGate.

Active self ligation: They use a flexible component to entrap the archwire. This flexible component constraint the archwire in the archwire slot and has the ability to store and subsequently release energy through elastic deflection. This imparts a light and continuous type of force on the tooth and its supporting structures, resulting in precise and controlled tooth movement.

Examples are In-Ovation "R", SPEED, Time, Inovation X, Lotus plus DS, Sensation, Cabriolet etc.

III. History and Evolution

Self ligating brackets are resurging from the early 20th century. The patents for the first attachment i.e., Boyd Band bracket was filed by Charles E Boyd in 1933. James. W. Ford has filed a patent for the Ford lock design manufactured by the Dee gold company of Chicago. Illinois. Its production was abandoned because it was too expensive and bulky.

The continued interest in developing self ligating brackets led to the **Russell attachment**, which was developed by Dr. Jacob Stolzenberg.[2] This bracket had a flat-headed screw that snugly seated in a circular, threaded opening in the face of the bracket. Since Dr.Stolzenberg was ahead of his time, the concept of self-ligating brackets fell more or less into obscurity until the early 1970s.

In 1971, Dr.Jim Wildman developed the Edgelok bracket, which had a round body with a rigid labial sliding cap. The rigidity of this outer fourth wall rendered the bracket "passive" in its interplay with the archwire.[5] The Edgelok was the first passive self-ligating bracket, and the first to enjoy any sort of commercial success.

Dr.Herbert Hanson was creating prototypes by 1976 became the basic SPEED design. After four more years of design refinement and clinical trials, the bracket was introduced in the market in 1980.[6] The SPEED bracket is active bracket features a curved, flexible "Super-Elastic Spring Clip" that wraps occluso-gingivally around a miniaturized bracket body. The labial arm of the Spring Clip, which forms the flexible fourth wall of the bracket slot.[7]

In 1986, the self-ligating Activa bracket, designed by Dr.Erwin Pletcher which had an inflexible, curved arm that rotated occluso-gingivally around the cylindrical bracket body. The arm could be moved into a "slot-open" or "slot-closed" position with finger pressure alone.[8]

In 1995, Time bracket was designed by Dr.Wolfgang Heiser, similar to SPEED bracket in appearance but its design and mode of action are different. Time features a rigid, curved arm that wraps occlusogingivally around the labial aspect of the bracket body.[9]

The Twin Lock bracket by Dr. Jim Wildman was introduced in 1998. Its flat, rectangular slide, housed between the tie wings of an edgewise twin bracket, is moved occlusally into the slot-open position with a universal scaler. It then slides gingivally with finger pressure to entrap the archwire in a passive configuration.[6]

Similar designs were introduced in 1996 and 1999 by Dr.Dwight Damon . The Damon SL and the Damon 2 are both edgewise twin brackets; the difference between these two generations is that the first featured a labial cover that straddled the tie wings, while the second incorporates a flat, rectangular slide between the tie wings.[8,10]

The In-ovation bracket introduced in 2000 similar to the Damon design with featured tie-wings. This resulted in a rather bulky bracket . The eligiloy spring clip makes the In-Ovation an active appliance.[10]

In 2004, Smart clip was introduced which consists of nitinol clips that open and close through elastic deformation of the material when the archwire exerts a force of the clip. the bracket contains no bracket door or latch.[11]

In 2006 Forestadent quick was developed by Dr.Bjorn Ludwig in both active and passive types. Externally passive brackets differentiated from active by a vertical marks on metal ligature wing. It consist of snap flexible spring, is opened with probe and optimized, anatomically base prevents rocking of the bracket during positioning.[12]

Damon Aesthetic (2009) is a translucent passive bracket with totally clear design made of strong polycrystalline alumina (PCA), an inert material impervious to staining or discoloration. A nickel-titanium Ni-Ti spring keeps the slide open and close positions.[13]

Smartclip SL3 (2009) introduced with less clip force, adhesive precoated framework and fluoride discharge property. Tandemarchwires has shown best results with this appliance.[14]

The Cabriolet passive-active bracket (2010) includes a ceramic body and stain steel hinge for quality, a metal slot inserts for lessened friction, and a polymer snap-on door for simple opening and shutting and enhanced patient comfort. Each bracket incorporates a centered T-hook for elastics.[15]

The harmony lingual bracket (2011) modified bonding pads and mechanically shaped archwires that move teeth productively and precisely. The bracket body is intended to ensure its self-ligating clip, which offers passive, interactive, or active ligation, depending upon wire size.[16]

The Sensation Active Ceramic Bracket (2012) created from a durable and translucent ceramic material and highlights a rhodium-covered treated steel clip settles opening and shutting forces of the bracket clip, bringing about quicker archwire changes.[17]

The Forestadent's BioQuick bracket (2014) presently includes a lower profile and rounder edges for enhanced patient comfort. The upgraded clip's thickness has been expanded by 20%, making it more strong and ready to withstand disfigurement while giving better control of angulation, rotation, and torque.[18]

The new Carriere SLX system (2014) offers an advanced variant of the Damon solution with enhancements in bracket arrangement, torque control, and accuracy finishing. They provide low profile and occlusally opening doors; visual signs including six horizontal and five vertical references are intended to help guarantee exact bracket arrangement.[19]

Empower 2 (2016) had incorporated micro-etched bonding pads and a thicker clip to expand wire-seating power while staying away from clip disfigurement.[20]

In-Ovation X (2017) holds a similar core design and treatment standards as inovation with improvements including a streamlined shape and a diminished profile and occlusal impression. There is an updated encased-clip system and shut gingival bracket base to reduce calculus accumulation.[21]

Double slot brackets(2017) were ntroduced by United States Patent and Trademark Office . This interactive slot has dimensions of 0.018" X 0.028" or 0.022" X 0.028" and the passive is 0.020" X 0.028"[22]

Many new and esthetic self ligating brackets were introduced in the recent past, but they met with limited success commercially.

Bracket	Year
Russel 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
Lancer Praxis Glide	2006
Ortho Organisers Carrière LX	2006
Lancer praxis glide	2006
Smart Clarity SL bracket	2007
Vision LP	2007
Discovery brackets	2007
Damon Q	2009
Damon Aesthetic	2009
Smart clip SL3	2009
Cabriolet Self-Ligating Bracket	2010
Harmony lingual bracket system	2011
Sensation Active Ceramic Bracket	2012
BioQuick Self-Ligating Bracket	2014
Carriere SLX	2014
Empower 2	2016
In-Ovation X	2017
Double slot brackets	2017

IV. Properties of self-ligation system

1. Lateral expansion: The use of passive self-ligation results in a significant reduction in the use of anchorage devices because of no frictional resistance by ligatures. The force of the arch wire is not transformed or absorbed by the ligatures and the necessary expansion can be achieved by the force of the arch wires. Tooth alignment therefore place minimal stress on the periodontium and the possibility of iatrogenic damage to the periodontium is reduced. Various studies report a greater change in arch width dimension with the use of self-

ligating brackets. They appear to lead to an increase in interpremolar or molar distance. Scott et al[23] reported that the intercanine width increased, while the intermolar width did not show an increase, with self- ligating bracket. According to the authors, this was related to the forward sliding of the molars into a narrower part of the arch. Fleming et al[24], Pandis et al (2010)[25] and Pandis et al (2007)[26] reported a greater expansion in the intercanine, interpremolar and intermolar regions as compared to the conventional system..

2. FRICTION: Friction is affected by the kinematics of the surfaces in, Externally applied loads and/or displacements, environmental conditions such as temperature and lubricants, surface topography, Material properties. During space closure, frictional force generated at the bracket/arch wire interface impedes the desired movement. The loss of applied force is seen strain on anchorage demands and leads to a reduction in the speed of tooth movement. Up to 60 percent of the applied force is dissipated as friction so. an adequate translating force must be applied in order to overcome the frictional force.[27]

Schumacher et al stated that friction was determined mostly by the nature of ligation and not by the dimensions of the different arch wires. Friction is related to the applied normal force, which is influenced by the degree of tension of the ligature engaging the arch wire into the slot and the coefficient of friction between the ligature and the arch wire material.[28]. Shivapuja and Berger found that self-ligating brackets generated less friction than conventional brackets.[29]

Read- Ward et al found that self-ligating brackets produced less friction only under certain conditions.[30] Thomas S, Birnie DJ, Sherriff M confirmed extremely low friction with Damon brackets compared to both conventional pre-adjusted and also Tip-Edge brackets.[31]

3. Archwire engagement: Full engagement is a feature of self-ligation because a clip/slide is either fully shut or closed. Unintentional partial engagement of the archwire is not possible. There is no issue of decay as elastic ligatures. However, security of ligation will depend on the clip/slide being robust and not inadvertently opening. Secure, full archwire engagement maximizes the potential long range of action of modern low modulus wires and minimizes the need to regain control of teeth. The combination of low friction and secure full engagement is particularly useful in the alignment of very irregular teeth and the resolution of severe rotations. This relationship between friction and derotation has been described by Koenig and Burstone, low friction permits rapid alignment and more certain space closure. Modern, low modulus wires substantially enhance the ability to harness these benefits.[32]

4. Chairside assistance and ligation/ archwire removal time:

Self-ligating brackets increased the speed of ligation. Voudouris reported a fourfold reduction in archwire removal/ligation time with prototype, Interactwin brackets which lead to the commercially available In-Ovation brackets.[11] Harradine found statistically significant, but clinically very modest savings in ligation/re-ligation time with Damon SL, an average of 24 seconds per archwire.[33] Berger J Byloff FK found that the total opening and closing time per arch was less than one minute for self ligating brackets while ligatures required about 6-7 minutes and elastomeric ligatures nearly 2 minutes. The time saving aspect was readily apparent regardless of which bracket was employed.[34]

5. Cost and treatment efficiency: Manufacturers claim that treatment can be achieved more quickly and more effectively, and that the brackets in combination with the recommended archwires exert lower forces and there is consequently less risk of root resorption. Self-ligation is also thought to allow better oral hygiene and cause less discomfort during treatment. A number of claims favouring efficiency are shorter chairside time, shorter overall treatment time, hygienic and easier to keep clean, longer intervals between adjustments, and requires fewer staff.

Eberting et al from intra-practitioner differences in three practices found an average reduction in treatment time of 7 months (from 30 to 25) and seven visits (from 28 to 21) for Damon SL cases compared to conventional ligation. The final average ABO occlusal regularity score was slightly better for the Damon cases.[35]

Point/Counterpoint on treatment efficiency:

According to Fleming and O,Brien citing from 9 randomised control studies and 2 systemic reviews concluded that self ligation did not significantly increase the treatment efficiency and treatment efficiency depends on appliance type, compliance, biologic age, and bone remodeling, with biologic processes.[36]

Harradine proposed increase on clinical efficiency with self-ligation because of the core features of security of ligation, lower resistance to sliding, and more rapid and convenient archwire changes remain and are increasingly supported by good studies. The most effective use of these advantages is still being explored, and the design of the brackets themselves has, as with functional appliances, continually and significantly improved.[37]

V. Archwires sequence

The authors mainly use the following wires:

- 0.012 NiTi SE
- 0.016 NiTi SE
- 0.016 × 0.022 NiTi SE

optional: 0.016/0.018 SS or 0.016 × 0.022 TMA

- 0.018 × 0.020 NiTi SE

optional: for space closure/opening depending on the anchorage/torque requirements: 0.018 × 0.025 SS/0.019 × 0.025 SS

- 0.021 × 0.025 NiTi SE Biofinisher

With the more pronounced plateau differences between austenite and martensite in high-quality alloys such as Sentalloy or HANT, a further reduction in the total number of archwires is possible. A moderately crowded dentition could therefore be treated with the following sequence:

- 0.018 Sentalloy
- 0.018 × 0.025 Sentalloy
- 0.017×0.025 stainless steel or 0.019×0.025 stainless steel

VI. Advantages of Self ligation system

1. **Secure robust ligation:** It is very resistant to inadvertent loss of ligation as good as wire ligatures.

2. Full bracket engagement: The arch wire can be fully engaged in the bracket slot and maintained. Wire ligatures do not stretch to an extent that engagement once achieved at ligation is subsequently lost, so they can meet this requirement.

3. Quick and easy to use: This is the principal reason for the enormous decline in conventional ligation. The use of wire ligatures added almost 12 minutes to the time needed to remove and replace two archwires. This is the largest and very understandable reason why self ligation was popularised in recent times.

4. Low friction: The forces generated by wire ligation still reach high and very variable levels that are thought to be optimal for tooth movement. Enhanced orthodontic tooth movement is achieved with lower friction levels in self ligation system.

5. Easy attachment of elastic chain: Conventional brackets have tie-wings which make attachment of elastic chain and if desired, elastomeric ligatures, convenient. The recently developed self-ligating brackets all have tie-wings.

6. Assistance to good oral hygiene: Elastomerics accumulate plaque more than tie-wires do. The ends of wire ligatures are, however, an additional obstacle to oral hygiene. Self ligation brackets eliminate plaque retention at these sites.

7. Comfortable for the patient: Self ligating brackets are more comfortable to the patient since the wire ligatures require careful tucking in of the ends to avoid soft tissue trauma, and can occasionally be displaced between appointments and cause discomfort.

VII. Limitations of various systems

1. Edgelok brackets: Edgelok brackets were the first self-ligating bracket to be produced in significant quantities. Disadvantages included inadequate rotational control, bulkiness, and some inconvenience with opening and closing the slide.

2. SPEED brackets: Early brackets were handicapped by clips, which could too easily be displaced or distorted. These drawbacks have been successfully addressed, but combined with the inherent unfamiliarity for clinicians of a bracket with no tie wings; these aspects probably hindered the wider popularity of SPEED in previous years.

3. Mobil-lock brackets: Mobil-Lock brackets had a rotating cam, which was turned with a "screwdriver," thus covering part of the labial surface of the slot. A major limitation was the narrowness of the resulting labial face of the slot gave poor rotational control .Another problem was the difficulty of access to open and close premolar brackets with the straight screwdriver.

4. Activa brackets: Activa brackets had a rotating slide, which therefore gave a concave inner radius to the labial surface of the slot. This increased the effective slot depth with small diameter wires, diminishing labio-lingual alignment with such wires. The slide was wider than average bracket, which reduced the interbracket span with the consequent disadvantages. The absence of tie wings was a nuisance when placing elastomeric chain and the unfamiliar shape of base made bracket positioning difficult.

5. Time 2 bracket: The Time clip rotates into position around the gingival tie wing and rotates toward the occlusal rather than the gingival wall of the slot. Early versions suffered from displacement of the clips. The negative effect of such initial problems were sometimes hindered subsequent popularity even when the problems have been very largely overcome

6. Damon SL brackets: These brackets were a definite step forward, but suffered two significant problems - the slides sometimes opened inadvertently and they were prone to breakage..
7. Damon 2 brackets: They retained the same vertical slide action and U-shaped spring to control opening and closing, but placed the slide within the shelter of the tie wings. These developments almost completely eliminated inadvertent slide opening or slide breakage and led to a further acceleration in the use of self-ligation. However, the brackets were not immediately and consistently very easy to open and this aspect of functionality is important to the new user.
8. Damon 3 and Damon 3MX brackets: Early brackets suffered a high rate of bond failure, separation of metal from reinforced resin components, and fractured tie wings. Such difficulties did not prevent the enthusiastic adoption of these brackets. The recently launched all metal Damon D3 MX bracket has clearly benefited from manufacturing and clinical experience with previous Damon brackets.
9. System R brackets: System R brackets originally called In-Ovation brackets, are very similar to the SPEED bracket but of a twin configuration with tie wings. In 2002, smaller brackets for the anterior teeth became available i.e., In-Ovation R (Reduced, referring to the reduced bracket width) and this narrower width was effective in terms of greater interbracket span.. 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 archwire are competing for space with the bracket clip.
10. Smartclip bracket: It provides easy insertion and removal through the jaws of the clips but must also prevent inadvertent loss of ligation for both small, flexible archwires and large, stiff archwires. The force required for insertion and removal of thick stainless steel wires from SmartClip brackets was uncomfortably high. A recent modification has addressed this difficulty by lowering the effective stiffness of the spring clips.

VIII. Conclusion

Although self ligating brackets might have an impact on our profession, we should consider ourselves as craniofacial biologists. Too many orthodontists have a mechanistic view of orthodontics. In this regard, SL bracket systems are only a tool that we use today; therefore, they are just a component of orthodontics. orthodontics deals with science/evidence, psychosocial issues, record taking, diagnoses, treatment, treatment outcomes, artistry, enhancements, and quality-of- life issues. In the future, we know for certain that there will be change. Therefore, we should be adaptable and prepared for knowledge to be undone, reworked, and revised.

References

[1]. Birnie D, Harradine NW. Introduction. Semin in Orthod 2008; 14:1–4.
[2]. Stolzenberg J. The Russell attachment and its improved advantages. Int J Orthod Dent Child 1935 ; 21: 837-840
[3]. Cacciafesta V, Sfondrini MF, Riccardi A, Scribante A, Klersy C, Auricchio F. Evaluation of friction of stainless steel and esthetic self-ligating brackets in various bracket-archwire combinations. Am J Orthod Dentofacial Orthop 2003; 124:395-402
[4]. Voudouris JC. Interactive edgewise mechanisms: form and function comparison with conventional edgewise brackets. Am J Orthod Dentofacial Orthop 1997; 111: 119-40
[5]. Gottlieb EL, Wildman AJ, Lang HM, Lee IF, Strauch EC Jr. The Edgelok bracket. J Clin Orthod 1972;6:613-23.
[6]. Harradine N. The History and Development of Self-Ligating Brackets. Semin in Orthod 2008;14:5-18.
[7]. Hanson GH. The SPEED System: A report on the development of new edgewise appliance. Am J Orthod 1980;78:243-265.
[8]. Heiser W. A new orthodontic philosophy. J Clin Orthod 1998; 35: 44-53
[9]. Birnie D. The Damon passive self-ligating appliance system. Semin in Orthod 2008;14:19-35.
[10]. Scott P, DiBiase AT, Sherriff M, Cobourne MT. Alignment efficiency of Damon3 self-ligating and conventional bracket systems: a randomized clinical trial. Am J Orthod Dentofacial Orthop 2008;134: 470-479.
[11]. Stolzenberg J. The efficiency of the Russell attachment. Am J Orthod Oral Surg 1946;32:572-82.
[12]. Geron S. Self-ligating brackets in lingual orthodontics. Semin in Orthod 2008;14:64-72.
[13]. Miles PG. Self ligating vs conventional twin brackets during en masse space closure with sliding mechanics. Am J Orthod Dentofacial Orthop 2007;132: 223-225.
[14]. Miles PG. SmartClip versus conventional twin brackets for initial alignment: is there a difference? Aust Orthod J 2005; 21: 123-127.
[15]. Berger J. The influence of SPEED bracket's self-ligating design on force levels in tooth movement. Am J Orthod Dentofacial Orthop 1990; 97: 219-228.
[16]. Voudouris JC. Seven clinical principles of interactive twin mechanisms. Journal of clinical orthodontics. J Clin Orthod 1997;31:55-65.
[17]. Sensation™ Active Ceramic Self-Ligating Bracket System. Available at https://www.orthotechnology.com/pdf/Productinfo/Sensation_Bracket_Doctor_Brochure.pdf. (Last accessed on 2020 Apr 30, 5:15 pm)
[18]. Ron Roncone. Self-Ligating Brackets: To Use or Not to Use? Available at: https://www.orthodonticproductsonline.com/2014/01/ormco-releases-022-slot-self-ligating-bracket-option/ (Last accessed on 2020 Apr 30, 5:20 pm)
[19]. What are self-ligating braces? Carriere SLX Self- Ligating Braces. Available from https://www.henryscheinortho.com/999-256-SLX-Patient-Education.pdf/ (Last accessed on 2020Apr 30, 5:30 pm)
[20]. American Orthodontics' Empower® 2 Self Ligating metal brackets. Available from http://www.americanortho.com/empower.html (Last accessed on 2020 Apr 30, 5:40 pm)

[21]. In-Ovation X Self-Ligating Metal Bracket Design Features and Advantages. Available at https://www.dentsplysirona.com/en-gb/explore/orthodontics/self-ligating-brackets/in-ovation-x.html (Last accessed on 2020 Apr 30, 5:45 pm)
[22]. https://www.duploslot.com.br/ last visited at 15/05/2020 06:40 a.m
[23]. Harradine NWT. Self-ligating brackets: where are we now? JO 2003; 30: 262-273
[24]. PS Fleming, DiBiase A, Sarri, Lee R- Comparison of mandibular arch changes during alignment and leveling with 2 preadjusted edgewise appliances. Am J Orthod Dentofacial Orthop 2009; 136:340-7.
[25]. Pandis N, Polychronopoulou A, Katsaros C, Eliades T. Comparative assessment of conventional and self-ligating appliances on the effect of mandibular intermolar distance in adolescent nonextraction patients: a single-center randomized controlled trial. Am J Orthod Dentofacial Orthop 2011; 140:86-102.
[26]. Pandis N, Polychronopoulou A and Eliades Theodore. Self-ligating vs conventional brackets in the treatment of mandibular crowding: A prospective clinical trial of treatment duration and dental effects. Am J of Orthod Dentofacial Orthop 2007;132:208-215.
[27]. Heo W, Baek SH. Friction properties according to vertical and horizontal tooth displacement and bracket type during initial leveling and alignment. Angle Orthod 2011;81:653-61
[28]. Schumacher HA, Bourauel C, Drescher D. The effect of the ligature on the friction between bracket and arch. Fortschritte Der Kieferorthopadie. 1990 Apr;51(2):106-16.
[29]. Shivapuja PK, Jeff Berger. A comparative study of conventional ligation and self-ligation bracket systems. Am J Orthod Dentofacial Orthop 1994 ; 106: 472-480
[30]. Readward GE, Jones SP, Davies EH. A comparison of self-ligating and conventional orthodontic bracket systems. Br J Orthod 1997; 24:309-317
[31]. Thomas S, Sherriff M, Birnie D. A. comparative in vitro study of the frictional characteristics of two types of self-ligating brackets and two types of pre- adjusted edgewise brackets tied with elastomeric ligature. Eur J Orthod 1998;20:589-596.
[32]. Koenig HA, Burstone CJ. Force systems from an ideal arch-large deflection considerations. Angle Orthod 1989;59:11-6
[33]. Voudouris JC. Interactive edgewise mechanisms: form and function comparison with conventional edgewise brackets. Am J Orthod Dentofacial Orthop 1997; 111: 119-40
[34]. Berger J, Byloff FK. The clinical efficiency of self-ligated brackets. J Clin Orthod 2001; 35: 304-310.Kapur R, Sinha PK, Nanda RS. Frictional resistance of Damon SL bracket. J Clin Orthod 1998; 32:485-489.
[35]. Eberting JJ, Straja SR, Tuncay OC. Treatment time, outcome, and patient satisfaction comparisons of Damon and conventional brackets. Clin Orthod Res 2001; 4:228-234.
[36]. Fleming PS, O'Brien K. Self-ligating brackets do not increase treatment efficiency. Am J Orthod Dentofac Orthop. 2013 Jan 1;143(1):19.
[37]. Harradine N. Self-ligating brackets increase treatment efficiency. Am J Orthod Dentofac Orthop 2013 Jan 1;143(1):16.

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