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Self-Ligating Bracket Systems: Are they Truly Low-Friction Bracket Systems?

Niha Naveed*[1], Kannan Sabapathy[1]

[1*]Department of Orthodontics and Dentofacial Orthopaedics, Sree Balaji Dental College & Hospitals, India.

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***Corresponding Author:** Dr. Niha Naveed, Department of Orthodontics and Dentofacial Orthopaedics, Sree Balaji Dental College & Hospitals, India.

Abstract

Orthodontic tooth movement can be conceived as teeth sliding on a wire like pearls sliding on a string. Friction between the wire and the bracket absorbs some of the force, leaving an unregulated amount to act on the teeth. Friction is defined as the resistance to motion when one object moves tangentially against another. The amount of friction is likely to be determined by the bracket's design, wire material, and wire cross-section that significantly influences the forces acting in a continuous arch system. In orthodontics, the word "self-ligation" refers to an orthodontic bracket's ability to engage itself with the archwire, reducing friction by eliminating the ligation force. The edgewise slot in these bracket systems is closed off by a mechanical lock integrated into the bracket. Practitioners need to decide whether self-ligation will be beneficial to their specific treatment plan for each individual patient. To make this decision, they need to know if friction between brackets and archwires is significantly reduced by self-ligation in a clinically meaningful quantity and also if this reduction is limited to certain circumstances.

Keywords: Orthodontic brackets, Self-ligation, Friction, Forces.

Introduction

Friction is described as an opposing and parallel force when one surface moves over another. There are 2 types of friction: static and kinetic. The force that is to be overcome to initiate movement is static friction, and the force encountered during motion is kinetic. Frictional forces are generated at the bracket-archwire interface of preadjusted appliances during leveling and aligning and space closure.

Self ligating tends to address two important concerns of orthodontists today. A decrease in frictional resistance, both static and dynamic, has to benefit the hard and soft tissues, whereas a decrease in the time of arch wire removal and insertion addresses both ergonomic and economic considerations. The self ligating bracket systems are advantageous in that they do not promote poor oral hygiene, as with elastomeric ties, and eliminate any chance of soft tissue laceration to both the patient and the orthodontist from the use of stainless steel tie wires. Besides enhancing public relations between the orthodontist and the patient with respect to both patient care and infection control in the oral cavity, a self ligating system is also appreciated by the support staff, both at the chairside and in sterilization.

Friction between the bracket and archwire has gained importance since the increased use of sliding mechanics that followed the development of the pre adjusted edgewise systems. Since friction reduces the effectiveness of tooth movement along the wire, significant efforts were made to lower friction in orthodontics Frictional resistance between archwire and brackets is determined by many factors and varies with

- wire to bracket angulation,
- archwire size and material,
- mode of ligation ,
- Bracket width,
- surface roughness and
- Dry or wet state.

Do Self-Ligating Brackets Produce Less Friction?

There have been numerous studies in the literature that have evaluated the frictional forces of self-ligating bracket systems over the years. One of the landmark studies was by Drescher et al. who considered bracket width to play an inferior role in frictional forces. Tipping is a constant phenomenon during sliding tooth movements. Thus, teeth will tip until contact is established between the archwire and the diagonally opposite corners of the bracket wings. Friction increases with angulation for all bracket/wire combinations. As archwire size increases, frictional forces between the archwire and the bracket slot also increase. Speed TM bracket, at 2.032 mm, was by far the narrowest of the brackets tested. The Time2 TM and In-Ovation R TM brackets had the widest slot dimensions at 2.946 and 3.000 mm, respectively, while the Damon3 TM had an intermediate width of 2.667 mm.If bracket width was the primary variable in determining frictional resistance, one would expect the Damon3 TM bracket to produce mean resistance forces somewhere between that of the narrow Speed TM and the wider Time2 TM and In-Ovation R TM brackets.

While the occluso gingival height of the slot for all the brackets used was 0.022 inches, the Damon3 TM was unique in that its slot was 0.027 inches deep, as opposed to the standard 0.028 inches for the other brackets. The smaller bucco lingual slot dimension means that as the tooth rotates around its long axis under application of a force, the buccal cap will contact the archwire sooner than with the standard slot depth. Therefore, a smaller contact angle will be created between the archwire and the buccal cap. This would lead one to believe that for a given archwire size the Damon3 TM may have a slight advantage over other brackets that possess a standard 0.022 × 0.028 inch slot.

Krishnan et al stated all brackets are to have the lowest frictional force with a wire dimension of 0.018 × 0.025 inch. Friction of the self ligating brackets using wire with a dimension of 0.018 × 0.025 inches was 45 – 48 per cent lower than with 0.017 × 0.025 in a .018 slot and 0.019 × 0.025 inch in a .022 slot. Friction of the conventionally ligated brackets showed a 14 per cent or less reduced friction with 0.018 × 0.025 inch wire compared with 0.017 × 0.025 in .018 slot and 0.019 × 0.025 inch wires in .022 slots. The self ligating metal brackets showed lower frictional forces with a 0.018 × 0.025 inch wire than conventionally ligated brackets, whereas conventionally ligated brackets showed lower friction with 0.017 × 0.025 and 0.019 × 0.025 inch wire.

Damon SL II brackets produce significantly lower static and kinetic frictional resistances than both conventional SS and aesthetic SLB in a study by Budd et al. The reason for reduced friction values is the self ligating cap does not press against the wire and when the cover is locked the slot is essentially converted into a tube, consequently friction values are similar to those produced by conventional stainless steel. The variability of friction among self ligating brackets is probably due to the different clip mechanisms.

While the Speed, In Ovation, and self ligating Time bracket feature an active clip mechanism, the Damon 2 bracket has a passive mechanism. The Time bracket can be used as a self ligating bracket or as a conventionally ligated bracket, thereby allowing direct comparison of friction. The self ligating Time bracket showed the largest frictional differences of all self ligating brackets between the three different wire dimensions. This might be due to the effect of tilting, which is much lower with self ligating brackets and with smaller wire dimensions.

Self ligating brackets are claimed to eliminate or minimize the force of ligation at the bracket wire interface, therefore, it is imperative to evaluate the frictional features of contemporary self ligating brackets with different archwire alloys. An in vitro study showed that all 4 self ligating brackets had significantly lower static and kinetic frictional forces than conventional pre adjusted brackets in all combinations of archwire alloys. However, intragroup comparisons of the self ligating brackets showed that the effect of archwire alloy was significant with the various modes of self ligation. The positive contact of the active spring clip with the archwire in the active versions is likely to produce higher friction than the passive appliance designs.

The influence of archwire alloy in friction for self ligating brackets was evident when NiTi wire was used. In this case, static and kinetic frictional forces were significantly greater than for SS. Thomas et al also noticed high frictional forces for active and passive self ligating brackets with NiTi wire compared with SS. However, Damon SL II and Smart Clip of the passive groups and In-ovation and Time of the active group had distinct differences in frictional parameters compared with NiTi. This was not similar to the pattern observed for self ligating brackets with SS wire. Yeh et al evaluated Damon SL II and Smart Clip with NiTi archwires in various cross sections, with first order rotation, second order intrusion, and third order labial crown inclinations. They observed no significant bracket differences, once binding occurred in the second order distances. But, in ideal archwire alignment, brackets with passive designs (Damon SL II and Smart Clip) differed significantly in mean values of frictional resistance with NiTi archwires. The TMA had the highest frictional force in both the active and passive designs. The high friction associated with TMA wire is attributed to the high titanium content and the surface reactivity that cause adherence during sliding mechanics. The surface texture of NiTi wire is rougher than TMA and SS, but frictional characteristics do not follow a similar pattern. Frictional forces for active and passive self ligating brackets with different archwires increased in the order of SS, NiTi, and TMA.

Elastomeric modules lose approximately 50% of their initial force within 24 hours of load application, and thereafter the force decreases to 30% to 40% after 4 weeks. But the in vivo aging of these materials by plaque accumulation, biofilm adsorption, enzymatic degradation, and structural alterations might outweigh the minimal benefit of reduced friction obtained with modules over a period of time.

The Damon 2 self ligating brackets produced less friction than the other ligation methods, followed by the coated modules. There was no significant difference between the frictional resistances of brackets ligated with regular uncoated, silicone impregnated, and easy to tie modules. Speed self ligating brackets produced less friction than regular uncoated, conventional silver, and standard silver modules. The frictional properties of coated modules were not significantly affected by repeating the test 5 times or by storage in saliva for a week. Single elastic module produces a ligation force of 50 to 150 g. Various methods have been used to reduce the friction of ligation, such as stainless steel ligatures and self ligating brackets. Stainless steel ligatures produce variable ligation forces and are time consuming to place. Some self-ligating bracket systems can lead to reduced treatment times and low frictional resistance as measured in the laboratory, but they are more costly. Modules coated with covalently bonded Metafasix (Super-slick, TP Orthodontics, LaPorte, Ind) have been claimed to reduce the friction of ligation by 60% compared with uncoated modules with similar elastic properties from the same manufacturer, although others have reported that coated modules did not produce less friction than uncoated brands.

In sliding mechanics, the bracket on the crown of the tooth tips to contact the archwire, and binding occurs at this interface. When food impacts the archwire during mastication, it causes archwire deflection or cuspal flexion, thereby releasing this binding and facilitating tooth movement. The significance of the critical contact angle in sliding mechanics was described by Kusy and Whitley. They determined that the critical contact angle is a parameter specific to each archwire bracket combination that can be considered the boundary between classical frictional behavior and binding related phenomena. While evaluating brackets with active and passive designs in various second order angulations, Thorstenson and Kusy found that, at values of angulation above the critical angle, binding increased proportionately irrespective of the self-ligating design of the bracket.

Frictional forces differ betweeen the materials that are used for making these brackets. The frictional forces are lesser in stainless steel self ligating brackets when compared to polycarbonate slb and the conventional ss brackets. Metal insert ceramic brackets generated significantly lower frictional forces than did conventional ceramic brackets, but higher values than stainless steel brackets. Beta titanium arch wires have higher frictional resistance than stainless steel and nickel titanium brackets. All brackets show higher static and kinetic frictional forces as the wire size increases. The proper magnitude of force during orthodontic treatment will result in optimal tissue response and rapid tooth movement.

Effect of the finish of the bracket slot surface has an effect on the frictional properties of the brackets. Large differences in surface roughness could affect resistance to movement by increasing the frictional coefficient of the material. Under a scanning electron microscope, the Damon SL bracket shows smoother surface detail than the Mini-Twin. Although both brackets are manufactured from 17-4 PH stainless steel, the Damon SL bracket is made by metal injection molding, while the Mini-Twin is investment cast. Steel SL brackets were consistently reported to show lower friction compared with ceramic and polycarbonate conventional brackets. This is probably due to the increased roughness and porosity of ceramic, which leads to a higher coefficient of friction compared with stainless steel. The Damon SL bracket showed significantly lower kinetic frictional forces ($p < .0001$) than the Mini Twin bracket with both wires (Fig. 2, Table 1). With the nickel titanium wires, the Damon SL brackets had a mean friction of 15.0g, compared to 41.2g for the Mini-Twin brackets. With the stainless steel wires, the Damon SL brackets produced a mean friction of only 3.6g, compared to 61.2g for the Mini Twin brackets.

The wire alloy and the size and shape of its section seem to have a significant influence on friction, as 0.017 × 0.025 inch TMA, 0.019 × 0.025 inch NiTi, and 0.019 × 0.025 inch SS showed a significantly higher frictional force when compared with 0.016 and 0.016 × 0.022-inch NiTi archwires, suggesting that, generally, larger rectangular archwires generate higher friction than round small archwires. When coupled with 0.016 inch NiTi wire, the Damon SL II brackets showed significantly lower friction compared with all other groups, while

Victory Series brackets showed significantly higher friction. With 0.016 × 0.022 inch NiTi, the self-ligating brackets (Time and Damon SL II) generated significantly lower friction than Victory Series brackets and Slide ligatures, while, with 0.019 × 0.025 inch NiTi and 0.019 × 0.025 inch SS, Slide ligatures generated signifi cantly lower friction, compared with the other groups. There was, however, no significant difference among the other groups. When comparisons among the different types of archwires were performed, the thicker rectangular archwires (0.017 × 0.025 inch TMA, 0.019 × 0.025 inch SS, 0.019 × 0.025 inch NiTi) showed a significantly higher level of frictional force when compared with 0.016 inch and 0.016 × 0.022 inch NiTi.

The bracket design is highly significant when examining the frictional characteristics of self ligating bracket systems The Time2 TM bracket only showed a significant increase in resistance to movement while sliding on the 0.019 × 0.025 inch SS archwire. It is the difference in the ligating mechanism that is responsible for the significantly larger mean resistance force of the Time2 TM bracket with the 0.019 × 0.025 inch SS wire. The wire dimension in the bucco lingual direction appears to be a more important factor in the friction generated by self ligating brackets.

With the exception of the Damon3 TM bracket, increases in the bucco lingual dimension generally resulted in significant increases in the mean resistance force generated. The passively ligated Damon3TM bracket system consistently demonstrated levels of resistance to movement that were either not statistically significantly different or were statistically signifi cantly lower than any of the other three brackets tested. The actively ligated Speed TM bracket system consistently demonstrated levels of resistance to movement that were statistically significantly higher than any of the other three brackets tested for any given archwire.

The self ligation design (passive versus active) appears to be the primary variable responsible for the frictional resistance generated by self ligating brackets during translation. Passively ligated brackets produce less frictional resistance however; this decreased friction may result in decreased control compared with actively ligated systems. The Damon3 TM bracket consistently demonstrated the lowest frictional resistance to sliding, while the Speed TM bracket produced significantly more frictional resistance than the other brackets tested for any given archwire. Damon SL bracket has a locking spring clip slide over the slot that holds the archwire securely in place. Unlike the conventional elastomeric ligature, this slide allows the wire to lie passively in the slot, reducing the normal component of force.

Sims et al and Reicheneder et al also allowed tipping of the brackets relative to the wire in their studies, but both studied only passive SL brackets. This may imply that passive SL brackets may exert less friction than active ones when round wires are used in specific clinical situations.

Friction is often held accountable for slowing down the rate of tooth movement and potentially causing loss of anchorage. Rather than occurring as a continuous, smooth, gliding process, tooth movement associated with sliding mechanics is known to occur as a series of minute tipping and uprighting movements. Because the force initiating motion is applied at a distance from the centre of resistance (CR), a moment is created that causes the tooth to tip until contact is established between the archwire and diagonally opposing aspects of the bracket slot. Following these initial movements, the interaction of the bracket (and ligature) with the archwire causes the tooth to upright and derotates and the cycle is repeated as long as the initiating force remains in effect.

Canine retraction (perhaps the most common clinical application of sliding mechanics) implies tooth movement on a segment of the archwire rigidly supported on either side of the canine. The Speed TM bracket consistently produced the greatest amount of resistance to sliding; the Damon3TM bracket consistently produced the least amount of resistance for all tested wires.

Resistance to sliding was investigated for 3 self-ligating brackets having passive slides and 3 self-ligating brackets having active clips. For each bracket, the resistances to sliding were measured at 14 second-order angulations, which ranged from _9° to _9°. Both the dry and the wet (human saliva) states were evaluated at 34°C. The critical contact angles for binding were determined for all products and ranged from 3° to 5°. Above each critical angle, all brackets had elastic binding forces that increased at similar rates as angulation increased and were independent of bracket design. At second order angulations that exceeded the critical angle, brackets with active clips that had a low critical angle had more resistance to sliding than did brackets with active clips that had a higher critical angle.

Brackets with passive slides that had a high critical angle exhibited the lowest resistance to sliding, but could do so at a cost of some loss of control. Nonetheless, self-ligating brackets represent a compromise between friction and control; ie, self-ligating brackets produce frictional forces that are more reproducible than do conventionally ligated stainless steel brackets.

When a sliding mechanism is used in orthodontics, the resistance to sliding (RS) generated between the interface of the bracket slot and the archwire can influence the force delivered to the teeth. The sliding mechanism in orthodontics is important not only for space closure, but also for the initial stage of leveling and aligning because the archwires must slide through the brackets. The amount of RS (resistance to sliding) is proportional to the normal force produced by the ligation method, which could be conventional stainless steel ligature wires, elastomeric O-rings, or self ligating slides or clips. In this passive configuration, the brackets with passive slides exhibit small to no RS in either the dry or wet states as indicated by the near-zero slopes and intercepts. The passive region for the Damon bracket extends farther than that for the Activa and Twinlock brackets; thus sliding mechanics can be used without significant resistance when the Damon bracket is at a greater relative to the archwire. The brackets with active clips exhibit greater RS values than those with passive slides in either the dry or the wet states. For all brackets with active clips, the RS in the dry state is lower than in the wet state. Because the SPEED bracket exhibited the greatest RS in either state, it must possess the highest effective ligation force. The RS values for the brackets with passive slides are approximately zero.

Archwire size and shape appeared to have a more profound influence on mean resistance force generated when actively ligated brackets were considered. In general, resistance to movement increased with increases in archwire dimension and/or changes in cross-sectional shape of the archwire (from round to rectangular). The bucco lingual dimension (thickness) of the wire appeared to be a more important factor than the occluso- gingival dimension in determining the frictional resistance of self-ligating brackets under the conditions of the study.

Rectangular wires produced an increased friction even in SL brackets is that, as the bracket slot is filled, the differences between SL and conventional brackets are minimized. This is related to less tipping allowed before teeth are straightened back by the wire resilience. This cycle occurs at a faster rate with more slot play. The friction when related to slot size is more a function of the dimension of the archwire engaged.

While Victory brackets generated significantly higher friction when coupled with 0.016 inch NiTi compared with the two self-ligating brackets (Damon SL II and Time), no signifi cant differences among Victory Series, Damon SL II, and Time brackets were observed when engaged with the rectangular archwires. This seems to indicate that the design of the self- ligating brackets results in low friction only when engaged with round wires, and not with rectangular archwires. However, it should be noted that Damon SL II showed the lowest level of friction with round wires, compared with all the other combinations, suggesting that, among the considered archwire – bracket combinations it remains the bracket of choice when lower frictional force is required during the alignment phase. They showed similar friction compared with self ligating brackets when coupled with 0.016 inch NiTi, 0.016 × 0.022 inch NiTi, and 0.017 × 0.025 inch TMA, that is low friction with round wires and high friction with rectangular wires.

Each of the self ligating brackets have their own unique advantageous over the other. Each of them have been compared to the others and the conventional brackets and studied. For the SPEED brackets Shivapuja and Berger, Kim et al, Henao and Kusy, Read-Ward et al and smith et al compared it with conventional brackets on various arch wires and concluded that it had lower frictional resistance. A significant decrease in the force level required for the SPEED bracket arch wires when compared with elastomeric and steel tie ligation in both metal and plastic bracket systems. SPEED showed lesser frictional forces because of its resilient spring clip, reduction in size of the bracket and surface anatomy of the arch wire slot. For the Damon Brackets Cacciafesta et al, Tecco et al, Thomas et al, Voudouris, Franchi et al, Smith et al, and Kim et al reported that Damon SL brackets generated lower frictional resistance than conventional steel brackets.

Griffiths et al reported that Damon brackets showed lower resistance to sliding compared with ceramic conventional brackets. But Henao and Kusy found higher friction than conventional brackets when coupled 0.016× 0.022 in and 0.019×0.025 inch archwires. The low level friction of the Damon self ligating bracket system encourages more rapid leveling and tooth alignment, allowing longer appointment intervals and reduced overall treatment time. Damon2 brackets compared with traditional brackets, although the advantage became marginally insignificant with more severe crowding. Reduced force levels and friction associated with Damon3 brackets do not appear to result in more rapid tooth alignment, either initially or in the later stages of orthodontic treatment. For the Time SL brackets Thomas et al, Smith et al, Tecco et al, Henao and Kusy and Kim et al reported that Time SL brackets yielded lower friction than steel conventional brackets when coupled with either round or rectangular archwires. But Henao and Kusy and Redlich et al reported that for the 0.016× 0.022 in and 0.016× 0.025 in archwires, Time produced higher friction compared with conventional brackets. For the In Ovation brackets Kim et al, Henao and Kusy reported lower friction for In-Ovation SL brackets compared with conventional brackets. For the Active brackets Shivapuja and Berger, Read- Ward and Sims et al reported that Activa SL brackets showed lower friction than conventional brackets.

For the Edge lock brackets Shivapuja and Berger reported that Edge-lok SL brackets showed lower levels of friction than conventional brackets. For the Smart clip brackets Kim et al, Yeh et al and Franchi et al reported lower friction for Smart-Clip brackets compared with conventional brackets. For the Opal SL brackets Franchi et al and Reicheneder et al reported lower friction for Opal-M brackets compared with either steel or ceramic conventional brackets. Cacciafesta et al and Reicheneder et al reported that the frictional forces of Oyster ceramic SL brackets were similar to conventional steel brackets lower than conventional ceramic brackets when tested with either 0.017×0.025 in or 0.019×0.025 in archwires. Franchi et al reported lower friction for Carriere SL brackets compared with conventional brackets when coupled with 0.019×0.025 in archwires.

Thorstenson and Kusy compared a series of selfligating brackets with conventionally ligated brackets in a similar but more extensive way, studying the effect of friction to binding on resistance to sliding in a steadystate laboratory model under both dry and wet (saliva) conditions. They reported that, with both conventional and self ligating brackets, binding also increased as the wire-bracket angulation increased. This shows that resistance to sliding is only with friction because the bracket is held steady (no angulation). In that condition, resistance to sliding was lower for all the self- ligating brackets than for a conventional bracket tied in with a wire or an elastomeric ligature, and lower for brackets with a passive clip than an active one.

Choi et al studied effects of self-ligating brackets on the surfaces of stainless steel wires following clinical use by atomic force microscopic investigation. It provides the three-dimensional (3D)configuration with quantitative information regarding of the surface morphology. Several studies reported that frictional force is related to a number of factors as follows: (1) archwire appliances –the material, surface area and size, stiffness, and roughness;(2) bracket appliances –material, slot width and depth, shape, and interbracket distance; (3) archwire-bracket interface –the ligating material and ligating method and (4) biology and physiology – saliva, plaque and erosion, bite force and frequency, and alveolar bone loss. With these factors, the material of the bracket and archwire are the main factors determining friction. The order of changes in surface roughness with the use of 0.019×0.025 SS archwires treated, with Damon 3MX SS self-ligating brackets was least followed by Kosaka conventional SS brackets followed by with Clippy-C ceramic self-ligating brackets. Ceramic brackets lead to more morphological changes in 0.019×0.025 SS archwires than SS brackets without regard to the ligating method.

Thariq V. K et al analyzed the frictional forces generated by three types of self-ligating brackets; two passive (Damon 3MX and Smartclip) and one interactive (Empower) when compared to conventional orthodontic brackets using two arch wire dimensions 0.016 NiTi wire and 0.019X0.025 inch stainless steel wire. Results showed that self- ligating brackets had less friction when compared with conventional brackets with both round and rectangular wires. Among the passive self-ligating brackets, Damon 3MX showed the least friction when tested both with round and rectangular wires when compared to Smartclip. The frictional resistance does not remain the same when tested both with round and rectangular wires, for the interactive self- ligating bracket. All brackets showed higher frictional forces as the wire size increased.

Kumar et al conducted a multi-center in- vitro study to evaluate frictional resistance of titanium, stainless steel, ceramic and ceramic with metal insert brackets with varying dimensions of stainless steel wire. The orthodontist seeks an archwire–bracket combination that has both good biocompatibility and low friction. The material used in this study were Ti, SS, Ceramic and CMI with 0.018″ slot manufactured with zero-degree tip and −7° torque premolar brackets (3M, Unitek) and SS wires of varying dimensions (0.016″ round, 0.016 × 0.016″ square, 0.016 × 0.022″ rectangular and 0.017 × 0.025″ rectangular).The specimen population in each center composed of 160 brackets and wires. Differences among the all bracket/wire combinations were tested using (one-way) ANOVA, followed by the student Newman Keuls multiple comparisons of means ranking (at $P < 0.05$) for the determination of differences among the groups. Results showed that Ti bracket in combination with 0.017 × 0.025″ SS rectangular wire produced significant force levels for an optimum orthodontic movement with least frictional resistance.

Pillai et al conducted a study to investigate the frictional resistance on use of conventional stainless steel, radiance ceramic brackets, Empower self- ligating brackets and composite brackets of 0.22" inch slot in combination with 0.019x0.025" inch brackets. Ceramic brackets showed highest frictional resistance followed by stainless steel brackets composite brackets and self- ligating brackets showed lowest frictional resistance.

Kyu-Ry Kim et al investigated the static (SFF) and kinetic frictional forces (KFF) in sliding mechanics of hybrid bracket systems that involve placing a conventional bracket (CB) or active self- ligating bracket (ASLB) on the maxillary anterior teeth (MXAT) and a passive SLB (PSLB) on the maxillary posterior teeth

(MXPT). Placing Passive Self Ligating Brackets on the Maxillary posterior teeth resulted in significant SFF and KFF reductions in cases with Conventional Brackets on the Maxillary Anterior Teeth, but not in cases with Active Self Ligating Brackets on the Maxillary anterior typhodont model.Kim et al 2019 [129] analyzed the surface composition, roughness, and relative friction of metal clips from various ceramic self-ligating brackets. Six kinds of brackets were examined. The control group (mC) consisted of interactive metal self-ligating brackets while the experimental group (CC, EC, MA, QK, and WA) consisted of interactive ceramic self- ligating brackets. Atomic force microscopy-lateral force microscopy and scanning electron microscopy-energy- dispersive X-ray spectroscopy were used to analyze the surface of each bracket clip. All the clips in the experimental groups were coated with rhodium except for the QK clip. The results showed that the QK clip had the lowest average roughness on the outer surface, followed by the MA, EC, WA, and CC clips. However, the CC clip had the lowest average roughness on the inner surface, followed by the QK, WA, MA, and EC clips. The QK clip also had the lowest relative friction on the outer surface, followed by the MA, EC, CC, and WA clips. Likewise, the CC clip had the lowest relative friction on the inner surface, followed by the QK, WA, MA, and EC clips. The surface roughness and relative friction of the rhodium-coated clips were generally higher than those of the uncoated clips.

Javier Moyano et al did an in vitro simulation to know the variables that affect arch displacement in CL and SL brackets—active (ASL) and passive (PSL)—and analyze if static friction values are affected by bracket design, arch wire section, kind of ligature, and use of a friction reducer agent (FRA) in a wet state. Results showed that higher static friction values are found in CL compare to ASL and PSL brackets, in the latter, lower values were found. CL brackets using metallic ligature show the highest static friction values with a great variability. Use of HY wire does not reduce static friction values in ASL and PSL,while in CL brackets with elastic ligatures, values were reduced significantly. Use of an FRA reduces static friction values in ASL but not in PSL.In the case of CL reduction,the effect is higher with SS than with HY wires, and with metallic ligatures, the values descend to ASL data.

The clinical advantage of reduced resistance to sliding should be a reduction in the amount of time to align the teeth and close the spaces. Several clinical studies have investigated this. Pandis et al investigated the time needed to correct mandibular crowding with conventional vs Damon2 self- ligating brackets. They concluded that “there was no difference in the time required to correct mandibular crowding between self-ligating Damon2 and conventional edgewise brackets.” In a similar study, Miles et al concluded that the Damon2 bracket “was no more effective at reducing irregularity than the conventional twin bracket with elastometric ligation.” Miles also did a limited clinical trial comparing SmartClip to conventional brackets, with the same conclusion.

Chung et al stated that increasing the torque from 0° to 15° produced significant increases in frictional resistance with all five sets of brackets and tubes. At 0°and 5°of torque, generally less friction was created within the passive than within the active self ligating bracket sets, and the conventional bracket sets with elastomeric ligation generated the most friction. At 10° of torque, apparently with wire-slot clearance eliminated, all bracket-and- tube sets displayed similar resistances, with one exception at 10°. At 15°of torque, one passive set and one active set produced significantly larger frictional resistances than the other three sets. At small torque angles, friction will tend to be less with passive than with active self ligating sets. A substantial increase in frictional resistance occurs if the torque in a bracket slot exceeds the third order clearance angle of the wire slot combination.

Thorstenson and Kusy studied frictional resistance (FR) to sliding of selfligating brackets versus conventional stainless steel twin brackets with second order angulation in the dry and wet (saliva) states. For the opened self ligating bracket in either the dry or the wet state, the SLB displays similar behaviour to that of the conventional bracket. The closed self ligating bracket exhibits little to no friction in the passive configuration for either the dry or the wet state. Overall, the FR at any angle is lower for the self ligating brackets than for the conventional. The greater critical contact angle of binding for the self ligating brackets than for the conventional brackets further reduces the FR at any angle above the critical contact angle.

The proper force magnitude during orthodontic treatment will result in optimal tissue response and rapid tooth movement. During mechanotherapy involving movement of the wire along the brackets, friction at the bracket archwire interface might prevent attaining optimal force levels in the supporting tissues. Therefore, an understanding of the forces required to overcome friction is important so that the appropriate magnitude of force can be used to produce optimal biologic tooth movement.

Time Plus brackets produced significantly lower frictional resistance than conventional stainless steel and Damon SL II self ligating brackets. Damon SL II brackets showed significantly lower frictional force than Time Plus brackets when tested with 0.014 inch NiTi, 0.016 inch NiTi, and 0.018 inch SS. On the other hand, when they were tested with 0.016 × 0.022 inch NiTi, 0.016 × 0.022 inch SS, 0.017 × 0.025 inch NiTi, and 0.017 × 0.025 inch TMA, they generated a significantly higher frictional force.

It was found from the above literature search that self ligating brackets generated significantly lower friction when coupled with round wires and significantly higher friction when coupled with rectangular archwires when compared with the other types of brackets. Beta titanium archwires had higher frictional resistance than did stainless steel and nickel-titanium archwires. No significant differences were found between stainless steel and nickel-titanium archwires. All brackets showed higher frictional forces as the wire size increased.

Conclusion

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. Thus by these properties of the self ligating brackets the treatment outcome is better.

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