Comparison of Frictional Resistances between Newer Self-ligating Brackets and Conventional Ligation Methods: An In-vitro Study

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CONTENTS

INTRODUCTION

Friction is defined as force acting tangentially at the surface of two moving bodies in contact8,39 When one moving object contacts another, the friction at their interface produces resistance to the direction of movement. i.e. friction acts parallel to, and opposing movement. When sliding mechanics is advocated friction generated between the bracket and the arch wire has a major impact on the force delivered to the teeth. Hence orthodontists need to have a quantitative assessment of frictional forces encountered at the bracket-wire interface, to overcome friction and to obtain an optimal biologic response, for efficient tooth movement.9 The desire, to be successful in applying optimum orthodontic force, has led to innumerable innovations in bracket designs, arch wire materials, and biomechanics. The orthodontic brackets have been modified in several ways, to decrease frictional resistances and improve the efficiency of sliding mechanics. These changes, initially focussed on bracket material, width and hence inter-bracket distance and ligation techniques. Conventionally, elastometrics and wire ligatures have been used for ligating arch wires to brackets.

They have their own disadvantages like17

- Failure to provide and maintain full archwire engagement.
- High friction.
- For elastometrics, the force (*and therefore tooth control*) decays and they are sometimes lost.
- Potential impediment to oral hygiene.

- Wire ligation is very slow.

To overcome the disadvantages of the conventional ligating technique, self-ligating brackets were introduced. They are ligature-less bracket systems that have a mechanical device built into the bracket to close off the edgewise slot. The unforeseen benefits of self-ligating bracket system are their low frictional resistance. Although the first self-ligating bracket was the Russel lock (*Stolzenberg 1935*) there has been renewed interest in the development of self-ligating brackets by manufactures and orthodontists since the mid 1970's. Several brackets were introduced like Edgelok (*Jim Wildman 1972*), SPEED system (*Herbert Hanson 1976*), TIME (*Wolfgang Heiser 1994*) Damon SL (*Dwight Damon 1996*)17

Self -ligating brackets are classified as **Active and Passive**177**.** **Active** brackets, have a sliding spring clip, which encroaches on the slot from the labial aspect, potentially placing an active force on the archwire, or a similar clip which rotates round a tie-wing for closure rather than sliding into place. **Passive** brackets, have a slide that opens and closes vertically, and creates a passive labial surface to the slot with no intention or ability to invade the slot and store force by deflection of a metal clip. Problems encountered with the initial generation of SL brackets include inadvertent opening of the active or passive clip slide breakage, increased bracket width - thus creating decreased inter bracket span, difficulty in opening and bulkier brackets.

Damon 2 an improvement of the original Damon SL brackets which are brackets with a passive vertical slide action, spring clip. The modification of the recent version include placement of the slide within the tie wings, MIM and reduced size and hence reduction in frictional force.

In-ovation R is an active self-ligating bracket, a modification of SPEED by its twin configuration. Manufacturers claim better ease of placement of archwire by its flexible yet active clip. The Time-2 is a modified version of Time by virtue of its clip guard which prevents inadvertent slippage. Manufacturers also claim reduced friction in-spite of its active configuration. Thus these brackets were chosen for this study. This study aims to explore the claims of these manufacturers and evaluate the commercially available newer self-ligating brackets, in view of reduction of friction and compare them with conventional ligation i.e. stainless steel ligatures and modules, with stainless steel and TMA (*Beta-Titanium*) wires.

REVIEW OF LITERATURE

Charles A Frank et al., (1980)5studied the frictional forces generated in an experimental simulation of the canine retraction procedure on a continuous arch-wire. Six independent variables were chosen for the study; arch wire size and shape, bracket width and style, second – order angulation between bracket and passive arch-wire, archwire material, ligature force on ligation and inter bracket distances. It was concluded that frictional resistance was found to be non-linearly dependent upon bracket/ arch - wire angulation. With small and generally non-binding angulations, bracket width and ligature force were the dominant influences on friction. As angulations were increased, producing binding between wires, this variable itself became the controlling parameter.

Dr. G Herbert Hanson (1986)19 cons idered SPEED brackets to be cosmetic, more hygienic and comfortable for the patient. Furthermore he found that it is easier to visually assess the position and orientation of the archwire slots of the miniature version. He attributes this partly to the fact that less of the tooth is obscured by the bracket.

Jan G Standard et al., (1986)21the kinetic co-efficient of friction for stainless steel, beta-titanium, nickel-titanium and cobalt-chromium arch-wires were measured on a smooth stainless or Teflon surface. Beta-titanium and stain less steel wires sliding against stainless steel and stainless steel wire on Teflon consistently exhibited the lowest dry and wet, friction values. Artificial saliva increased friction for stainless steel, Beta-titanium and nickel-titanium wires, sliding against stainless steel.

L D Garner et al., (1986)14 one hundred and eighty, bracket and arch wire combination of nitinol, beta-titanium, and stainless steel were compared as to assess the force required to overcome a simulated canine retraction assembly. Results showed a significantly larger force required during canine retraction using beta-titanium and nitinol when compared with stainless steel.

D C Tidy (1989)44 investigated frictional resistance to movement along a continuous arch wire. It was found that friction was proportional to applied load and inversely proportional to bracket width i.e. friction was greatest for narrow brackets. Arch wire dimension and slot size had little effect, on friction. Nitinol and beta-titanium arch wire produced frictional forces two and five times greater than those of stainless steel.

Dieter Drescher et al. (1989)8 a friction - testing assembly simulating three-dimensional tooth rotations was constructed to study factors affecting fric tional magnitude. Five wire alloys, (*standard stainless steel Hi-T.*

stainless steel, blue elgiloy, nitinol and TMA) in five wire sizes (0.016, 0.016x0.022, 0.017x0.025, 0.018 and 0.018x0.025 inch) were examined with respect to three bracket widths (2.2, 3.3 and 4.2 mm) at four levels of retarding force (0,1,2 and 3 N). The following factors affected friction in decreasing order; retarding force (*biologic resistance*), surface roughness of wire, wire size (*vertical dimension*), bracket width, and elastic properties of wire. The study recommended the application of 0.016x0.022 inch stainless steel wire combined with a medium (3.3mm) or wide (4.2mm) bracket for an arch - guided mechanism with a 0.018inch slot. The effective force of this arrangement had to increase two fold to overcome the friction. For TMA-Wire, however the effective force had to increase six fold, resulting in a hazardous overload of the anchorage units.

Sunil Kapila et al (1989)42reviewed the mechanical properties and clinical applications of stainless steel cobaltchromium, nickel titanium, beta-titanium, and multistranded wires. Stainless steel wires had formability, biocompatibility and environmental stability, stiffness, resistance and low cost. Cobalt -Chromium (Co-Cr) wires could be manipulated in a softened state and then subjected to heat treatment. Heat treatment of Co-Cr wires resulted in a wire with properties, similar to those of stainless steel. Nitinol wires had a good spring back and low stiffness. This alloy, however had a poor formability and finally betatitanium wires provided a combination of adequate spring back, average stiffness, good formability and could be welded to auxiliaries. Multi-stranded wires had a high spring-back and low stiffness when compared with solid stainless steel wires. Optimal use of these orthodontic wires could be made use, by carefully selecting the appropriate wire type and size to meet the demand of a particular clinical situation.

Don H Pratten et al. (1990)9 conducted a study to compare planar, static frictional forces among stainless steel and ceramic brackets. The results show that, under experimental conditions, ceramic brackets, nitinol arch wires and saliva all increased static frictional resistance.

Jeffrey L Berger (1990)24designed a study to compare the level of force required to move four distinct arch wires a similar distance, on six occasions, through four ligated bracket systems and the self-ligated SPEED bracket. The results consistently demonstrated a significant decrease in the force level required for the SPEED bracket with all four arch wires when compared with elastomeric and steel – tie ligation in both metal and plastic bracket system.

Sunil Kapila et. al (1990)41determined the effects of wire size and alloy on frictional force generated between bracket and wire during in vitro-translatory displacement of bracket relative to wire. Stainless steel (SS) cobalt-chromium (Co-Cr) nickel titanium (Niti) and beta-titanium wires of several sizes, along with medium twin and wid e twin stainless steel brackets in both 0.018 and 0.022 slots were evaluated. The wires were ligated into the brackets with elastomeric ligatures. The results showed that Beta-titanium and NiTi wires generated greater amounts of frictional forces than stainless steel or Co-Cr wires, for most wire sizes. Increase in wire size generally resulted in increased bracket wire friction. Narrow single brackets were associated with lower amounts of wire friction than wider brackets.

James R Bednar et al., (1991)20 an in vitro study of simulated canine retraction was undertaken to evaluate the difference in frictional resistance between stainless steel arch wires and steel and ceramic brackets with elastomeric, steel and self - ligation. The clinical significance of this study became apparent when stainless steel brackets were used on the posterior teeth and ceramic brackets were used on the anterior teeth and if sliding mechanics were used. The anterior teeth may be more resistant to movement than the posterior teeth because of the greater friction of the ceramic brackets. This could result in more posterior anchorage loss than would be expected if only one type of bracket was used.

Robert R Prososki et al., (1991)39measured surface roughness and static frictional force resistance of orthodontic arch wires. Nine Nickel - titanium alloy archwires were studied. One Beta-titanium alloy wire, one stainless steel alloy wire and one cobalt - chromium alloy wire were included for comparison. Frictional force resistance was quantified by pushing wire segments through the stainless steel self -ligating brackets of a four – tooth clinical model. The results showed that cobalt – chromium alloy and the nickel - titanium alloy wires, with the exception of sentalloy and orthonol, exhibited the lowest frictional resistance. The stainless steel alloy and the betatitanium wires showed the highest frictional resistance. The stainless steel alloy wire was the smoothest wire tested, whereas NiTi, Marsenol and Orthonol were the roughest.

Jeffrey L Berger (1994)25 said that SPEED appliance, since its inception, has undergone many significant design improvements.

Michael Tselepsis et al, (1994)33this study quantified the dynamic frictional force of sliding between different modern orthodontic brackets and arch - wires. From the multitude of factors involved in the frictional process, the following were selected for investigation: arch wire material, bracket material, bracket-to-arch wire angulation and lubrication artificial *saliva*). The frictional force involved in sliding, a ligated arch wire through a bracket slot was measured with a universal materials testing machine. Of the four factors investigated all were found to have a significant influence on friction. Polycarbonate brackets showed the highest friction and stainless steel brackets the lowest. Friction increased with bracket to arch wire angulation. Lubrication significantly reduced friction.

Prasanna Kumar Shivapuja et al (1994)35 conducted an in-vitro and clinical investigation to compare the frictional resistance between five different brackets namely standard metal twin, ceramic brackets, and three self-ligation brackets - Activa, SPEED, Edgelok with 0.018 stainless steel wire. Self-ligating bracket system displayed a significantly lower level of frictional resistance, dramatically less chair-side time for arch wire removal and inspection and promoted improved infection control, when compared with polymethylene elastomeric and stainless steel tie -wire ligation for ceramic and metal twin brackets.

Janet L Vaughan et al., (1995)22 studied the level of kinetic frictional forces generated during in-vitro translation at the bracket - wire interface between Mini- Taurus and miniature twin brackets and four different wires (stainless steel, cobalt - chromium, NiTi, Beta-Ti) with various cross - sections. The wires were ligated into the brackets with elastomeric ligatures. Time-dependent frictional forces were measured by a load cell and plotted on an X-Y-recorder. The results showed that for most wire sizes, lower frictional forces were generated with the stainless steel and cobalt-chromium wires than with the Beta-Titanium and NiTi wires. Increase in wire size generally resulted in increased friction. There were no significant differences between manufacturers for the sintered stainless steel brackets.

Nigel G Taylor (1996)34 in an In-vitro study assessed the frictional forces for three types of 0.022x0.028 inch brackets. Pre-adjusted stainless steel brackets, Activa brackets and SPEED brackets coupled with five wire sizes. The results showed that Activa brackets produced the least friction for all wires tested. SPEED brackets with round wires showed little frictional force while rectangular wires gave rise to higher forces at levels similar to those recorded with two standard straight wire brackets. The ratio of static to dynamic friction was remarkably consistent in all tests. Different methods of ligation were compared for their effect on static friction. Ligation with loosely placed ligatures or stretched modules reduced frictional forces in standard straight wire brackets, the Reduction being greatest for round archwires. Frictional forces recorded from archwires secured with elastomeric modules showed a steady reduction over a 3 - week period, depending on how long the module had been in position on the bracket.

G E Read ward et al., (1997)36 compared the static frictional resistance of three self-ligating brackets with a conventional steel- ligated Ultra - trimm bracket. The effects of arch - wire size, bracket/ arch wire angulation and the presence of unstimulated human saliva were Investigate.The study demonstrated that both increase in wire size and bracket/arch wire angulation resulted in increased static frictional res istance for all bracket types tested, but self -ligating brackets showed reduced frictional resistance in comparison to steel ligated brackets only under certain conditions.

Dwight H Damon (1998)10 compared the friction produced by three types of conventional twin brackets with three selfligating twins.When 0.019x0.025 stainless steel wires were drawn through the bracket, a conventional twin ligated with 0-rings produced 388 to 609 times the friction of passive self -ligating brackets. Conventional twins with metal ligatures were found to have friction values, more than 300 times those of passive self-ligating brackets. The active self -ligating bracket produced 216 times the friction of a passive self-ligating bracket.

Luca Pizzoni et al., (1998)11 studied the frictional resistance encountered in two self- ligating (*Speed, Damon SL*) and two conventional brackets (*Dentauram*). These brackets were tested with four wires. (*Stainless steel, Betatitanium* - *round and rectangular*). The result showed that round wires had a lower friction than rectangular wires. Beta-titanium wires had higher friction than stainless steel. The self -ligating brackets had a markedly lower friction than conventional brackets at all angulations. It was concluded that the selection of bracket design, wire material and wire - cross section significantly influences the forces acting in a continuous arch system.

Rupali Kapur et al (1998)12 a study was designed to compare the kinetic frictional force of Damon SL selfligating bracket with conventional mini-twin bracket along with 18x25 Niti and 19x25 stainless steel wires. The results showed that Damon SL bracket showed significantly lower kinetic frictional forces than the mini-twin bracket with both wires.

Susan Thomas et al (1998)43 investigated the frictional characteristics of two types of self ligating brackets - `A' company Damon SL and Adenta Time brackets and two types of pre-adjusted edgewise brackets - TP Tip - Edge and `A' company standard twin brackets. Five combinations of arch wire size and material were used (0.014 NiTi, 0.0175 multi-stranded stainless steel, 0.016x0.022 Niti, 0.016x0.022 stainless steel, 0.019x0.025 stainless steel wires. Results indicated that these self-ligating brackets produced less frictional resistance than elastomerically tied pre-adjusted edgewise brackets.

WolfGang Heiser (1998)45described the major features of ‘TIME' bracket. He said that early in treatment, when smaller wires were in place, the low friction of the `TIME' brackets permitted lighter forces to be used for moving teeth and unwanted rotations do not occur during retraction, because the spring clips and light forces control any rotation tendencies. Early torque control from the interactive springs clips allowed treatment to be finished sooner, the crown placement system made bonding easier and more accurate, and the spring clip permitted archwire changes faster. Taken together, the benefits of the `TIME' system meant shorter treatment time and reduced chair time.

Brian P Loftus et al., (1999)2 frictional forces during simulated sliding tooth movement were measured with a model that was representative of the clinical condition. Damon SL (*self-ligating*), one ceramic (*Transcend*) and one ceramic with stainless steel slot - clarity brackets were used, along with stainless steel, Nickel titanium and betatitanium Wires. The results showed that the conventional ceramic brackets generated significantly higher friction than the other brackets tested. Beta-titanium arch-wires produced higher frictional forces than nickel-titanium arch wires, but no significant differences were found between each of the two and stainless steel arch wires.

Robert P Kusy (2000)37 the geometry of the archwire and bracket defined a critical angle for sliding. Below this angle, sliding occurs with only classical friction opposing motion. Above this angle, sliding becomes more prohibitive as binding of the archwire in the bracket increasingly resists sliding until motion ceases. Thus to align and level to an angle other than critical angle unnecessarily subjects the patient and practitioner to longer treatment and more chair time. If teeth were aligned and leveled according to the critical contact angle, the resistance to sliding was minimized by self-ligating brackets. On the other hand if teeth were not aligned and leveled properly, the resistances to sliding of conventional and self-ligating brackets differ only by the amount of classical friction.

Glenys A Thorstenson (2001)15 the frictional properties of conventional stainless steel brackets that were coupled with rectangular stainless steel archwires and ligated with stainless steel ligature wires and the frictional properties of closed self-ligating brackets coupled with the same archwires, were compared in terms of second-order angulation. As a control, the frictional properties of the opened self-ligating bracket, which were ligated with stainless steel ligature wires, were measured. The results showed that in the passive configuration, the conventional brackets exhibited similar frictional resistance as the opened self-ligating brackets, whereas the closed selfligating brackets exhibited no friction. At all angles, the resistances to sliding of the closed self-ligating brackets were lower than those of the conventional brackets because of the absence of ligation force when the slide restrained the archwire.

Jeff Berger et al., (2001)23 the authors have designed a study to test the hypothesis that self-ligating bracket systems could reduce chair time in archwire changes. The self -ligated group included 20 patients for each of four different types of self-ligating brackets. SPEED (*active Spring clip*), Damon I (*slide cover*), Time (*rigid arm*), Twinlock (*labial slide*). The ligated group, using Mini-Twin brackets, comprised of 20 patients ligated, with stainless steel ties and 20 patients with elastomeric modules. The SPEED system reported to save a significant amount of time compared to conventional ligated brackets. The amount of time saved by any of the other 3 self-ligating brackets was similar. It was further concluded that selfligation was an extremely cost-effective treatment technique. The clinical advantages of self-ligating systems, including more efficient leveling, low friction, patient comfort, and minimal force - added even further to the time saving benefits of those brackets.

Glenys A Thorstenson et al., (2002)16 investigated the resistance to sliding for 3 self-ligating brackets having passive slides and 3 self-ligating brackets having active clips. (*Damon, SPEED, Twinlock, In-ovation, Time, Activa*). For each bracket, the resistances to sliding were measured at 14 second - order angulations, which ranged from -9o to +9o. Both dry and wet (human saliva) states were evaluated, at 34oC. The results showed, generally at second – order angulations, 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.

Cacciafesta V et al (2003)3studied the frictional resistance generated between stainless steel self-ligating brackets (*Damon SL II*) polycarbonate self-ligating brackets (*Oyster*) and conventional stainless steel brackets (*victory series*) and three different orthodontic wire alloys: stainless steel, nickel-titanium and beta-titanium in three different dimensions 0.016, 0.017x0.025 and 0.019x0.025. The results showed that stainless steel brackets generated significantly lower static and kinetic frictional forces than both conventional stainless steel and polycarbonate selfligating brackets, which showed no significant differences between them. Beta-titanium arch wires had higher frictional resistances than stainless steel and nickeltitanium arch wires. No significant differences were found between stainless steel and nickel-titanium arch wires. All brackets showed higher static and kinetic frictional forces as the wire size increased.

Darryl V Smith et al., (2003)7 studied the frictional resistance of various bracket archwire combinations. It was concluded that 1) ceramic brackets with and without metal slot had the greatest friction followed by metal brackets, active self-ligating brackets, variable self-ligating, brackets, and passive self-ligating brackets. 2) Stainless steel and braided stainless archwires measured greater friction than nickel- titanium 3) small dimension wires had less friction than larger wires, and round wires has less friction than rectangular wires. In addition, consideration of specific bracket - archwire coupling appear to reduce the frictional resistance with sliding.

Edward Mah (2003)11 Conducted frictional study with self -ligating brackets (*In-ovation, and Damon 2*), and conventional brackets (*Minitwin, Transcend 6000*).These 4 brackets were evaluated with 6 different archwires (0.018 Niti, 0.018 stainless steel 0.019x0.025 TMA, 0.018x0.025 S.S., 0.019x0.025 stainless steel, and 0.021x0.025 stainless steel). Results showed significant differences in dynamics friction among the different bracket types. The Damon 2 brackets produced significantly less dynamic friction compared with the In-ovation brackets. In general, the selfligating brackets produced significantly less static, kinetic and dynamic friction than did conventional brackets, and larger diameter archwires produced greater amounts of dynamic friction.

Kevin Mendes et al (2003)26they conducted a study in which ion-implanted and untreated nickel-titanium and beta-titanium wires were tested along with stainless steel wires as well as plastic and silicon coated nickel-titanium archwires. They were tested in treated (*ion implanted*) and untreated edgewise stainless steel brackets, SPEED selfligating Brackets and the uniquely designed synergy. The results suggested that ion implantations of nickel-titanium and beta-titanium wires as well as the bracket surface are effective means to reduce friction. An even greater reduction in friction could be obtained by offsetting the friction from the elastomeric ligation as with a bracket design like that of the synergy bracket and the use of ionimplanted wires. Low friction properties of active selfligating brackets (SPEED) necessitated the utilization of the correct combination of archwire and bracket.

Laura R Iwasaki et al., (2003)28 examined the effects of bracket ligation forces and mastication on friction when sliding a bracket along an archwire. The results suggested that vib ration introduced by mastication did not eliminate friction when sliding a bracket along an archwire. In addition, there was considerable intra operator variation in ligation forces, although ligation techniques were well controlled. Variations in Clinical ligation forces are likely to be equal or greater than those experimental data. These variations could affect treatment efficiency.

Lorne S Kamelchuck et al., (2003)30 the classic in vitro studies of frictional resistance mostly utilized straight – line traction applied to the wire - bracket ligation interface. Reports from those studies included relative quantification of either static or kinetic frictional resistance, but did not simulate the complexity of tooth movements observed with in- vivo sliding mechanics. In this study a prototype testing apparatus was designed, fabricated, assembled and its performance evaluated. It is concluded that the testing apparatus presented, has the ability to allow for a high standard of basic hypothesis testing, product development and quality control.

Max Hain et al. (2003)32 conducted an `in-vitro' study that investigated the effect of ligation method on friction and evaluated the efficacy of the new slick elastomeric modules from TP orthodontics, which were claimed to reduce friction at the module/wire interface. Slick modules were compared with regular non-slick modules stainless steel ligatures and SPEED self-ligating bracket system. The results, showed that SPEED brackets produced the lowest friction compared with the other three tested bracket systems when regular modules were used. The use of slick modules, however, with the entire ligated bracket types tested, significantly reduced friction to below the values recorded in the SPEED groups.

N W T Harradine (2003)17 conducted a study to explore the treatment efficiency of currently available self-ligating brackets and concluded that the currently available selfligating brackets offered the very valuable combination of extremely low friction and secure full bracket engagement

and at last, they delivered most of the potential advantages of this type of bracket. These developments offered the possibility of a significant reduction in average treatment time and also in anchorage requirements, particularly in cases requiring large tooth movements. Whilst further refinements are desirable and further studies essential, current brackets are able to deliver measurable benefit with good robustness and ease of use.

P Emile Rossouw et al (2003)13 stated that static and kinetic co-efficients of friction are reported to vary as functions of time and velocity, respectively. Orthodontic wire-bracket-ligation friction, of significantly low velocity and extended duration, is a dynamic physical parameter underestimated by the In-vitro analyses to date.

Robert P Kusy et al., (2003)38fluids other than saliva were used to quantify the sliding effectiveness of archwires within bracket slots to evaluate the efficacy of using artificial saliva. The co-efficients of friction were measured using four media: a control, dry state; whole human saliva; deionized water;

and artificial saliva (*Moi-stir, Orex, salivant,saliva substitute and xero-lube*). For these eight conditions, both static and kinetic co-efficients of friction were measured with two couples, each comprising of 21x21 beta titanium (TMA) archwire against a 0.022 polycrystaline alumina (Lumina) bracket. Conclusions drawn from these measurements indicated that only human saliva can be used to assess friction and its co-efficients in the wet state. The control, dry state ranked next, followed by the other fluid media.

Henao SP et al (2004)18 the frictional behavior of four conventional and four self-ligating brackets were simulated using a mechanical testing machine. Analyses of the two bracket types were completed by drawing samples of three standardized arch wires through quadrants of typodont models in the dry/ wet states. As nominal dimension of the arch wire increased, the drawing forces of all brackets increased at different rates. When coupled with a small wire the self-ligating brackets performed better than the conventional brackets. When coupled with larger wires, various designs interchangeably displayed superior performance. For maximum values between the dry and wet states, significant differences between ambient states existed only for the In-ovation brackets.

Khambay B et al (2004)27 investigated the effect of elastomeric type and stainless steel ligation on frictional resistance using a validated method. SS and TMA wires each with dimensions of 0.017x0.025 and 0.019x0.025 inches were used in combination with a self-ligating, Damon-2 bracket or a conventional pre-adjusted edgewise premolar stainless steel bracket without ligation. Four types of elastomeric module, purple, grey, Alastik or superslick and a pre-formed 0.09 inch stainless steel ligature were assessed as methods of ligation using pre-adjusted edgewise premolar stainless steel brackets. Damon-2 self ligating bracket and un-ligated conventional stainless steel bracket produced negligible mean frictional forces with any of the wires tested. For the 0.017x0.025 stainless steel, 0.019x.025 stainless steel or 0.019x0.025 inch TMA wires, stainless steel ligatures produced the lowest mean frictional forces. With the 0.017x0.025 TMA wire, purple modules produced the lowest mean frictional force. There was no consistent pattern in the mean frictional forces across the various combination of wire type, size and ligation method.

Clocheret K et al (2004)6 evaluated the frictional behaviour of 15 different arch-wires and 16 different brackets. The results indicated a significant difference between the evaluated wires and brackets, which ranged from 0.16 to 0.69 for the arch-wires and 0.39 to 0.72 for the brackets. This study can assist in the choice of the optimal bracket – wire combination with regard to friction.

Cash A et al (2004)4 studied the static and kinetic frictional resistance of eight different arch-wires coupled with stainless steel edge-wise brackets. 0.019x0.025 TMA colored beta- titanium, ion implanted beta – titanium, Timonium and stainless steel wires as a control were used for testing. The results showed that stainless steel wires produced the lowest frictional resistance followed by honeydew, ion implanted TMA, timolium with aqua, purple and violet producing frictional resistance as high as standard TMA.

SUMMARY AND CONCLUSION

This in-vitro study was undertaken to compare the kinetic frictional resistances offered by newer self-ligating brackets and to compare them with the conventional methods of ligation (*ligature ties and modules*).

The following conclusions were drawn from the results.

1. Damon –2 has the least friction among the newer self–ligating brackets for stainless steel and TMA wires.

2. In-ovation R has the highest friction followed by Time-2.

3. Conventional ligation with stainless steel ligation and modules showed similar range of frictional forces with no significant difference between them.

4. TMA wires have higher friction than stainless steel wires in all the bracket/ arch-wire combinations tested.

5. The self ligating brackets, In-ovation R and Time-2 shows higher friction than the conventional ligation methods.

The low frictional results of the Damon–2 suggested that the passive slide design may be the most accommodating of the bracket designs tested, albeit at the expense of some loss of control. Nevertheless the clinician has to decide on the ideal bracket/ arch-wire combination depending on the anchorage needs, root control and the amount of space closure, taking into consideration individual patient requirements.

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