EVALUATION OF STIFFNESS AND PLASTIC DEFORMATION OF DIFFERENT CLIPS/SPRINGS OF SELF LIGATING BRACKETS AFTER REPETITIVE OPENING AND CLOSURE MOVEMENTS

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DECLARATION BY THE CANDIDATE

TITLE OF DISSERTATION	EVALUATION OF STIFFNESS AND PLASTIC DEFORMATION OF DIFFERENT CLIPS/SPRINGS OF SELF LIGATING BRACKETS AFTER REPETITIVE OPENING AND CLOSURE MOVEMENTS.
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This is to certify that dissertation titled **"EVALUATION OF STIFFNESS AND PLASTIC DEFORMATION OF DIFFERENT CLIPS/SPRINGS OF SELF LIGATING BRACKETS AFTER REPETITIVE OPENING AND CLOSURE MOVEMENTS"** is a bonafide research work done by **Dr. Unais K.T** ,in partial fulfillment of the requirements for the degree of **MASTER OF DENTAL SURGERY** in the specialty of Orthodontics and Dentofacial Orthopedics.

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This is to certify that the dissertation titled **"EVALUATION OF STIFFNESS AND PLASTIC DEFORMATION OF DIFFERENT CLIPS/SPRINGS OF SELF LIGATING BRACKETS AFTER REPETITIVE OPENING AND CLOSURE MOVEMENTS"** is a bonafide research by **Dr. Unais K.T** Post Graduate student (M.D.S), Orthodontics and Dentofacial Orthopaedics (Branch-V), KSR Institute of Dental Science and Research, Tiruchengode, submitted to the **Tamil Nadu Dr. M.G.R Medical University** in partial fulfilment for the M.D.S degree examination (April 2018) under my supervision and guidance.

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INTRODUCTION

INTRODUCTION

Self ligating brackets do not require an elastomeric or stainless steel ligature but have an inbuilt mechanism utilizing a permanently installed movable component that can be opened or closed to secure the arch wire[70]. In majority of designs this mechanism has a metal labial face to the bracket slot which is opened and closed with an instrument or finger tip. Self-ligating brackets were developed in 1930's and different types have been commercially available to till date. Charles E. Boyd filed the first patent for self-ligating brackets in 1933. Edgelok bracket was the first commercially successful bracket introduced by A.J Wildman in 1971.The introduction of SPEED bracket which was the first active self-ligating bracket in 1970s was considered as a revolutionary invention in the field of orthodontics by Dr G. Herbert Hanson. Self-ligating bracket system had replaced the elastomeric and stainless steel ligatures and had proved to have many advantages over conventional brackets. Manufactures claim that frictional resistance is reduced in self-ligating system. Self-ligating brackets obviate the need for elastic and metal ligatures and thereby creates a low friction environment at bracket-arch wire interface. This allows better sliding mechanics and as a result overall treatment duration is decreased. Initially self-ligating brackets were made of stainless steel. Nowadays ceramic self-ligating brackets are available.

Based on the type of clip, self-ligating brackets can be divided into - active and passive self-ligating brackets. Pressure is exerted on the arch wire against slot base by active clip. At the same time the passive clip transforms the open slot into a tube using a closing mechanism[41]. There are not enough studies about the magnitude of force applied by the clip on the arch wire. Arguments are put forth that there might be relaxation of the force exerted by the clip after several times of repetitive opening and closing movements affecting the effectiveness of ligation ,but there is lack of evidence for this. Very few studies have been done to find out the clip stiffness and plastic deformation of the clip in self- ligating brackets. When these materials are exposed in the oral cavity, properties of the clip might be changed.Material composition of clip used in SLB's such as metals, alloys, NiTi and ceramics may undergo degradation in the oral cavity. This might adversely affects the effectiveness of the ligating mechanism of self-ligating brackets[54] . Aging of these materials in oral cavity occurs by calcification of adsorbed complexes of ions and proteinaceous matter which might alter the morphological, structural , compositional and mechanical properties of orthodontic alloys and polymers.[41]

Active and passive self-ligating brackets have different types of opening mechanism. The opening and closure forces of self-ligating brackets varies among different brands[49]. Other than the effects of intra oral aging, another problem arises from the potential effects of repetitive opening and closing movements of self ligating brackets throughout the treatment . A damaged clip especially in active/interactive types, affects the magnitude of force applied on the arch wire which hinders all the benefits of self- ligating brackets[19]. While considering the passive self-ligating brackets which has a sliding or a shutter like opening mechanism, which also exerts a slight pressure on the arch wire when heavier wire is placed in slot which is needed for the expression of torque mainly in the anterior region. Repeated opening and closing movements of the self-ligating brackets may produce some changes in stiffness or plastic deformation in the clip or sliding door of these brackets. It is useful to study such problems in these types of brackets .

An ideal self ligating bracket should provide ligation which is fast and secure and provides less resistance to tooth movement relative to arch wire [70]. But in addition to this such bracket should be easy to open and close with low forces during the arch wire insertion and removal . It should never open accidently, leading to loss of tooth control. It should have a ligating mechanism that never breaks or distorts throughout the treatment. It should have a properly open clip or slide position so that clip or slide does not hinder the view of bracket slot over actual placement of the arch wire. It should permit easy attachment and removal of all usual auxiliary components such as elastomeric chains, laceback ligatures without obstructing the clip or slide. It should have enough mesiodistal dimension to take advantage of the secure arch wire engagement and allow large inter bracket distance to reduce force levels and provide longer range of action . Current hypotheses about self ligating brackets claim that there is less incisor proclination during alignment in crowded cases. It also claims that they can achieve stable wider arches with better preserved bone levels and good periodontal health after treatment and also less need for extractions in borderline cases and easier class II correction through a lip-bumper [70]

Another advantage of self ligating brackets is their treatment efficiency. It was claimed that orthodontic treatment is faster in self ligating brackets. It was found that in one of the clinical study there was a mean reduction of four months in treatment time and four visits during active treatment time[47]. In another clinical study in three practices it was found that an average reduction in treatment time of six months and seven visits for Damon SL cases compared to conventional ligation[30]. Another claim of self ligating brackets is that they can achieve arch expansion than conventional brackets. But studies shows that effect of self ligating brackets on arches has similar effect and both brackets resolve crowding in a similar manner. It was found that lower incisors are proclined and a slight expansion (1.6 mm) had occurred at the molar region. However the wires used were different for the two bracket system used. For Damon 0.014×0.25" copper NiTi have a wider arch form and thicker compared to the 0.020" sentalloy arch wire in conventional bracket. So in this case the slight posterior expansion is attributed to the difference in arch wire forms and cross sectional thickness and not necessarily related to the bracket used. It has been argued that self-ligating brackets produce less frictional resistance than conventional brackets[67]. It was found that in one of the study Damon (SLB) brackets showed the lowest friction for all dimensions of wires followed by the Time (SLB) bracket. The 'A' company standard twin brackets produced the highest friction with all dimensions checked followed by tip edge bracket. All these results shows that self-ligating brackets produce less frictional resistance than elastomerically-tied pre-adjusted edge wise brackets.

The main disadvantage of self ligating bracket is that torque control is less and more difficult mainly with passive self ligating brackets[70]. This proposal is mainly based on the belief that labiolingual forces between the base of bracket and ligature system are a significant additional source of force couple which adds to the application of torque. In an active self ligating bracket the clip encroaches the bracket slot and expected to give an effective torque force at a smaller "slop" angle than a passive bracket. This has been investigated by Badawi et al[24]. He found that the active clip of an In-Ovation bracket provides enough force to reduce the "slop" by 7 degrees when 0.019×0.025 inch wire is inserted. For getting full advantage of the self-ligating brackets in one study , a hybrid system was used which included active self-ligating brackets in the anterior portion for more torque expression and passive self-ligating brackets in the posterior portion where there is a less need for torque.

The hypothesis tested in this study was whether self-ligating bracket clips become loose, flexible ,undergo any breakage or if there is any reduction in the stiffness or plastic deformation after repetitive opening and closing movements. .

AIM & OBJECTIVES

AIM AND OBJECTIVES OF THE STUDY

AIM:

The aim of this study is to evaluate the stiffness and plastic deformation of clips in four different self -ligating brackets after repetitive opening and closure movements.

OBJECTIVES:

1) To evaluate the stiffness and plastic deformation of the clips of four different self-ligating brackets before and after 50 cycles of repetitive opening and closure movements.

2) To evaluate the differences in stiffness and plastic deformation between the clips of Active and Passive self-ligating brackets before and after 50 cycles of repetitive opening and closure movements

3) To evaluate the tendency for breakage of clips in active and passive Self-ligating brackets, after 50 cycles of repetitive opening and closure movements.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Jeffrey L,Berger[28](1990):did an in vitro study which was designed to compare the level of force required to move four distinct archwires a similar distance on six occasions , through four ligated bracket system and self ligated SPEED bracket. He concluded that a highly significant reduction was observed in the force level required to move each of four arch wires a standard distance through the SPEED self ligating brackets when compared with the elastomeric and steel ligated 'A' company and American orthodontics bracket system when either rectangular steel or round braided arch wires were used.

James R. Bedner, Gary W Gruendeman[26](1993):evaluated the effects of bracket width and ligation technique on the moment production of conventional and self ligating brackets during axial rotation in an invitro study with simulated orthodontic model. They concluded that bracket width and ligation technique had a significant effect on moment produced. They found out that types of ligation such as tight steel ties, elastomeric or self ligating spring clip, had greater influence on moment produced than did bracket width. Self ligating spring clip bracket produced the least amount of force over the greatest range of axial rotation.

A.P.T.Sims, N.E waters et al[1] (1993): did an in vitro study to compare forces required to produce tooth movement using two self ligating brackets and a pre-adjusted bracket employing two types of ligation. This study concluded that friction in Activa brackets was lower by a factor of the order of 15 times when compared to SPEED brackets and by a factor of 40 times when compared to Mini twin brackets using the conventional elastomeric ligation . Friction was found to be lower by a factor of 50-70 % for archwire typically used during sliding mechanics for space closure in SPEED brackets when compared with their previously published work . Ligating arch wires with elastomeric ligatures in a ‘ figure of eight’ pattern increases resistance to sliding mechanics by a factor of 70-220 % depending on wire cross section.

Prasanna kumar,Jeff Berger[55](1994):compared frictional resistance in conventional and self ligation bracket systems. .They found a decrease in frictional resistance(both dynamic and static) in SLB’S. Time taken for arch wire removal and for insertion were also found to be less in SLB’S when compared with conventional brackets. Improved oral hygiene were found in SLB’S when compared with conventional elastic modules which sticks food debris. Soft tissue lacerations also avoided in SLB’S and found to have better infection control when compared with conventional brackets .They also found out significant less treatment time in SLB’S compared with conventional bracket system.

Jefry L.Berger[27](1994): described various integral components of the SPEED appliance and reviewed the function of each. The purpose of this article was to reacquaint the reader with the design and function of the SPEED appliance as it appears today. He found out that various improvements had occurred in the features like bond strength, spring clip, tip control , torque control, rotation control since its introduction.

Susan Thomas, Martyn Sheriff and David Birnie[67] (1998):evaluated the frictional characteristics of two types of SLB’S (‘ A Company Damon SL and Adenta Time brackets) and two types of pre-adjusted edge wise brackets (T P Tip edge and ‘ A’ Company standard twin brackets). Their results revealed that the Damon brackets shown the lowest friction for all dimensions of test wires followed by the ‘‘Time’ bracket. The‘ A’ Company standard twin brackets showed the highest friction with all wire dimensions tested, followed by the Tip edge bracket. Among all the brackets the 0.016×0.022 inch NiTI wires showed a higher frictional resistance than 0.016×0.022 inch stainless steel wires. All these results indicates that SLB’S produce less frictional resistance than elastomerically tied pre-adjusted edgewise brackets.

Luca Pizoni ,Gert Ranholt and Birte Melsen[34](1998): investigated the friction of SLB’S and beta –Ti wires as opposed to more conventional configurations. They found that round wires had a lower friction than rectangular wires, beta – Ti wire had a markedly higher friction than stainless steel wires and friction increased with angulations for all bracket wire combinations. They concluded that SLB’S had a markedly lower friction than conventional brackets at all angulations and SLB’S closed by capping of a conventional design displayed a significantly lower friction than SLB’S closed by a spring.

JJ Eberting, SR straja, OC Tuncay[30](2001):compared the effectiveness and efficiency of Damon SLB’S to those brackets ligated with either steel ligatures or elastomeric ‘O’ rings. They concluded that patients treated with Damon SL brackets had significantly lower treatment time and taken only fewer appointments and had significantly higher ABO scores than treated with conventionally ligated edge wise brackets.

N.W.T Harradine[47] (2001): compared the treatment efficiency with conventional fully programmed brackets and Damon SL brackets. He concluded that Damon SLB'S produced statistically and clinically significant reduction in treatment time and number of visits. Damon SL brackets showed significant levels of technical failures of ligation mechanism. Both types of brackets showed good and equivalent reduction in occlusal irregularity.

Glenys A .Thorstenson , BS and Robert P. Kusy[18](2001):evaluated the frictional properties of conventional stainless steel brackets that were engaged with rectangular stainless steel arch wires and ligated with stainless steel ligatures and frictional properties of closed SLB'S engaged with same arch wires were compared in terms of second order angulations. They concluded that opened SLB'S were comparable with conventional SS brackets when both were ligated with SS ligatures when tied with same ligature force. In passive configuration no resistance to sliding (RS) exists for the closed self ligating bracket. In active configuration the BI(elastic binding) component of RS(resistance to sliding) increases a similar amount per degree for SS conventional brackets and SS closed and opened SLB'S.

N.W.T. Harradine[41] (2003):reviewed the current situation regarding the self ligating brackets. He described the recent developments, clinical advantages and the imperfections. He concluded that currently available SLB'S offer extremely low friction and also secure full bracket engagement. They offer the chance of significant reduction in average treatment time and also in anchorage requirements in case of large tooth movements .

.**Max Hain, Dhoptakar, Peter Rock[39](2003):**evaluated the effect of ligation method on friction and evaluated the efficiency of new slick elastomeric modules from TP Orthodontics which are claimed to reduce friction at the module wire interface. They concluded that saliva lubricated slick modules can decrease the static friction at the module arch-wire interface by up to 60%, regardless of the bracket system. The SPEED brackets produced the lowest friction compared with other three tested bracket systems when regular modules were used. The use of lubricated, slick modules with any of the brackets tested found reduced friction to below SPEED values.

Sandra p. Henao, Robert P.Kusy [60](2004): evaluated the frictional resistance of conventional and self ligating bracket designs using standardized arch wires and dental typhodonts. They mentioned the factors such as types of arch wire alloy , dimension, angulation, ligation force, interbracket distance, bracket width and bracket slot influences friction.

Simona Tecco ,Felice Festa et al[65] (2005):compared the frictional resistance produced by conventional stainless steel brackets, self ligating Damon SL II brackets and Time- plus brackets coupled with stainless steel ,Ni-Ti ,beta-Ti arch wires in an in vitro study. They concluded that Damon SL II brackets produced significantly lower friction than the other brackets when tested with round wires and significantly higher friction than Time-plus when tested with rectangular arch wires. Beta –Ti arch wires produced higher frictional resistance than other arch wires. All brackets showed higher frictional forces as the wire size increased.

Theodore Eliades and Christoph Bourauel [71](2005): studied the variety and potency of various aging factors affecting the morphology, structure and mechanical properties of polymeric and metallic orthodontic materials. They displayed force transferred from the activated arch wire to a pre-adjusted bracket slot, as well as friction during free sliding. They declared that the chance for aging on spring component of self ligating brackets , adversely affect the ligation force while considering the intra oral surroundings. They demands more studies needed on these topic before establishing the advantages of self ligating brackets.

Peter G. Miles,Robert J.Weyant, Luis Rustveld [51](2006): compared the efficiency and comfort of Damon 2 brackets and conventional twin brackets during initial alignment. The study demonstrated that during initial phase of treatment, the Damon 2 bracket had 0.2 mm greater irregularity, so clinically it did not perform better than conventional twin bracket. They concluded that the Damon 2 bracket was no more effective at reducing irregularity than conventional twin bracket with elastomeric ligation. The Damon 2 brackets were firstly less painful than conventional twin bracket but were more painful when tying in the second arch wire.

Simona Tecco, Donato Di lorio et al[64] (2007):investigated the frictional resistance produced by conventional SS brackets(victory series), self ligating Damon SL II brackets. Their study showed that self ligating and victory series brackets showed different patterns depending on the section(round or rectangular) of the arch wire. They concluded that SLB'S displayed low friction only with round wires and not with rectangular wires.

Nikolaous Pandis, Christoph Bouravel and Theodore Eliades[43](2007):evaluated the effect of intra oral aging on the force exerted during engagement of a wire in to the slot in active SLB’S. They found that there is extensive relaxation of clip in some groups throughout the treatment but no permanent deformation. Their study described degradation in the ligating mechanism of brackets, resulting in the loss of stiffness of the clip which seem to be vary between products depending on the mechanotherapy and potential implications for the arch wire engagement in to the bracket slot.

Peter G Miles [52](2007): compared the rate of en mass space closure with sliding mechanic between passive self ligating smart clip brackets and conventional twin brackets ligated with SS ligatures. Their study demonstrated that rates of space closure were almost identical with the passive smart clip brackets and the conventional brackets tied with SS ligatures distal to extraction site

Lorenzo Franchi, Tiziano Baccetti et al[33] (2008): evaluated the frictional forces produced by 4 types of passive stainless steel SLB’S and by non conventional elastomeric ligatures(NCEL) and conventional elastomeric ligatures(CEL) during sliding mechanics. They found out that significantly smaller static and kinetic forces were produced by the SLB’S and NCEL(< 2g) compared with CEL (> 500g). Finally they concluded that SLB’S and NCEL are better alternatives for low friction during sliding mechanics.

Nigel Harradine[42](2008.): described an overview of history and development of self ligating brackets in his article. He gave a brief description of evolution of SLB’S which started in 1935 with the introduction of Russel Lock edge wise attachment by stolzenberg. New designs like ‘Time’ bracket introduced in Germany,1994, Damon SL bracket in 1996 and the Twin Lock bracket,1998.

Nikalaos Pandis, Maria Nasika et al[44] (2008): concluded that no differences should be anticipated for root resorption between conventional and passive SLB'S. Their study concluded that sex and age of adolescent patients are not related to the extent of external apical root resorption (EARR). They concluded that as the treatment duration increases chance for root resorption also increases.

Nikolaos Pandis,Theodore Eliades et al[45] (2008): assessed the magnitude of moments produced during rotational correction from different bracket system during the late levelling and alignment stage of orthodontic treatment. Their study concluded that a large variation in magnitude of moments exerted by self ligating and conventional brackets were observed in the simulated rotation correction of teeth, which depends on the geometry of dental arch, the tooth position and the rigidity of the closing component of the bracket slot.

Enver Morina,Theodore Eliades et al[12] (2008): evaluated the torque capacity of active and passive SLB'S and compared with metallic, ceramic and polycarbonate edgewise brackets. Their study suggest that SLB'S present reduced torquing moments compared with conventional ceramic brackets and higher torque loss compared with ceramic and selective stainless steel brackets. They also demonstrated that there were no significant differences between torque of incisors between two appliances such as Damon and conventional brackets.

Paola Gandhini, Linda Orsi et al[50] (2008): evaluated frictional forces generated by three different ligation methods in in vitro. Their study compared the friction produced by a passive SLB with frictional forces produced by an innovative type of UEL (unconventional elastomeric ligatures) on conventional brackets and by CEL (conventional elastomeric ligature in conventional brackets. Their result proved that both SLB and UEL on conventional brackets produced significantly lower frictional forces compared with CEL on conventional brackets. UEL are made with special polyurethane mix by injection molding.

Hisham M. Badawi,Roger W. Toogood et al[24] (2008): evaluated the torque expression of active and passive SLB'S. They found significant difference in the engagement angle between active and passive SLB'S. Torque started to be expressed at 7.5 degree torsion for active SLB'S and 15 degree of torsion for passive SLB'S. They found torque expression was higher for active SLB'S up to 35 degree of torsion. They concluded that active SLB'S are more efficient in torque expression than passive SLB'S.

Manu Krishnan,Sukumaran Kalathil,Kurian Mathew Abraham[36] (2009): evaluated the frictional forces in active and passive SLB'S with various arch wire alloys. They stated that frictional forces varies depending on type of ligation mechanism as well as arch wire used. They found out that static and kinetic frictional forces were lower for both active and passive designs than for conventional brackets. Maximum values were seen with beta-Ti arch wires and significant differences observed with between Ni-Ti and stainless steel arch wires. They concluded that with Ni-Ti and beta-Ti wires in passive appliances produce very less frictional resistance during guided tooth movement

PG Miles[53] (2009): concluded that the current prospective evidence regarding duration of treatment indicates that no clinically significant difference exists between pre-adjusted edgewise brackets and SLB'S . SLB'S have comparable effects on arch form to conventional brackets. SLB'S claim modest time saving when tying and untying compared with conventional brackets,but the time saving vary with specific design of the SLB'S used.

Currently, the evidences are limited and more potential clinical trials using identical wire sequences and mechanics are required.

Giancarlo Cordasco,Giampietro Farranato et al[17] (2009): investigated the frictional forces between brackets and arch wires with three passive SLB'S. They compared the results with conventional ligation including cluster module as well as ligature. Results showed that frictional forces generated from passive self ligation were significantly lower ($p < 0.01$) than those resulting from both elastic ligation and metallic ligation. No significant differences was found in frictional forces when compared between metallic and elastic ligation. They concluded that when the wires slide through passive SLB'S , the lighter frictional forces produced in one part of the arch increases aligning and levelling.

Sayeh Ehsani, Marie Alice Mandich et al[61] (2009): compared the degree of expressed frictional resistance between orthodontic self ligating brackets and conventional ligated brackets in vitro as reported in the literature. In these systematic review they concluded that when compared with conventional brackets, SLB'S produced lower friction when engaged with small round arch wires in the absence of tipping or torque in an well aligned arch. Sufficient evidence was not found to argue that with large rectangular wires, in the presence of tipping or torque and in arches with considerable malocclusion, SLB'S generated lower friction compared with conventional brackets.

Padhriag.Fleming,Ama Johal[48](2010): evaluated the clinical difference in use of SLB'S over conventional brackets. One of their study reported that less pain experienced with Damon SL III SLB'S. Considering bond failure rate there was no significant difference over others. Arch dimensional changes with self ligating system and conventional system was found to be similar. Identical levels of inter canine expansion and incisor proclination was found in both systems. It was found that during initial stages of treatment there was lower bacterial and streptococcal loads surrounding SLB'S compared with conventional brackets. SLB'S don't have any particular advantage regarding pain experience. There is insufficient evidence suggesting that orthodontic treatment is more or less efficient with SLB.

Stephanie shih- Hsuan chen, Geoffrey Michael Greenlee et al[66] (2010): The purpose of their systematic review were to recognize and review the orthodontic literature considering the efficiency, effectiveness and stability of treatment with SLBs compared with conventional brackets. They concluded that shorter chair time and slightly less incisor proclination found to be the only significant advantages of SLBs over conventional systems which are supported by current evidence.

Thomas W.Major,Jason P. Carey et al[72] (2011): investigated the third order torque on different types of SLBs by analyzing the brackets elastic and plastic deformation in relation with the expressed torque at varying angles of twist. They concluded that In-Ovation R had the least deformation due to torquing of the three investigated bracket types. Damon-Q and SPEED on average had approximately 2.5 and14 times greater maximum plastic deformation, respectively than did In- Ovation R.

Mariana Ribbeiro Pacheco et al[40] (2011): evaluated the friction of self-ligating brackets when subjected to sliding mechanics. Their study aimed to assess the static friction force generated in passive and active self-ligating brackets when engaged with round 0.018-in orthodontic arch wires and rectangular 0.017×0.025-in orthodontic arch wires during in vitro sliding mechanics simulation. They found out that low friction was generated in round wire in all types of self-ligating brackets. More friction was observed with active self-ligating brackets when engaged with rectangular wire when compared with passive self-ligating brackets which was similar to conventional brackets with same dimension wire.

Chase Prettyman,Al M. Best et al[6](2012): determined clinical differences between self ligating brackets and conventional brackets during orthodontic treatment, as perceived by orthodontists. They concluded that – the orthodontists participated in this study reported a perceived clinical difference between SLBs and conventional brackets with regard to orthodontic treatment. SLBs were preferred by orthodontists very often than conventional brackets due to many factors evaluated. The orthodontists bracket preference was significantly influenced by the number of patients they treated with SLBs , the number of cases it took them to become adapted to self ligating brackets and the average appointment intervals for both SLBs and conventional brackets

Paola GANDINI,Linda ORSI et al[49] (2013):mentioned the opening and closure forces of sliding mechanisms of different SLBs using Instron Universal Testing machine. Opening forces were observed between 1.1 N and 5.6 N where as the closure forces were observed between 1.57N and 4.87N. Significant differences were recognized among different brackets and between two prescriptions tested. They concluded that knowledge of different opening and closure forces of self ligating brackets can help the orthodontist in the clinical management of these brackets.

Collin Jacobs,Philipp F Gebhardt et al[7] (2014): determined the amount and severity of EARR (external apical root resorption), treatment time and extraction rate during orthodontic treatment with self ligating and conventional brackets. They concluded that there is no significant difference in the amount of EARR between patients treated with SLBs and non SLBs. Number of appointments did not display any difference between two groups where as the treatment time with SLBs was almost three months longer and also there was no evidence for a difference in the amount of extraction cases in the two groups.

Nouran F Seif Eldin, Mona Salah Fayed et al[46] (2015): compared how SLB and conventional system affecting alveolar bone thickness and type of tooth movement produced during leveling and alignment phase. They found that there was a statistically non significant increase in buccal inclination of the teeth accompanied by a non significant decrease in the surrounding buccal cortical thickness in both sides. They concluded that actual alveolar bone expansion was not obvious with the use of self ligating brackets in their study.

Grace Kelly Martins, Juliano Alves et al[19] (2015): investigated the stiffness and plastic deformation of active ceramic self ligating brackets clips after repetitive opening and closure movements. They found out that there was no significant difference in plastic deformation among the different bracket types used after 500 cycles of opening and closure. But there was significant differences on stiffness among the three types of brackets. WOW brackets had the highest mean values, In-Ovation C had the intermediate values, Quiklear brackets had the lowest values, regardless of 500 opening and closure movements . They concluded that repetitive controlled opening and closure movements of the clip did not change stiffness or cause plastic deformation.

Kyu- Ry Kim,Seung- Hak Baek[31] (2016): investigated the static (SFF) and kinetic frictional forces (KFF) in sliding mechanics of hybrid bracket systems which included the placement of conventional bracket (CB) or active self ligating brackets (ASLB) on maxillary anterior teeth and a passive SLB (PSLB) on maxillary posterior teeth. They came to this idea as the active SLB has more friction than passive SLB, as the friction is needed for torque expression in the anterior teeth. It was observed that a significant reduction in SFF and KFF when Passive SLB placed in posterior teeth in combination with CB in maxillary anterior teeth when compared with placement of active SLB in maxillary anterior teeth in combination with passive SLB in posterior teeth. They concluded to use conventional brackets on maxillary anterior teeth and passive self-ligating brackets on maxillary posterior teeth in the hybrid system. These data may be used to guide the development of hybrid bracket system that enables low friction during the sliding of an arch wire through the maxillary posterior teeth.

MATERIALS & METHODS

MATERIALS AND METHODS

MATERIALS

- **BRACKETS**

In this study 80 samples of self-ligating brackets were included and they were divided into 2 groups. Group 1 comprised of 40 samples of passive self-ligating brackets and group 2 comprised of 40 samples of active self-ligating brackets. The group 1 and group 2 were subdivided in to group 1a,1b and group 2a,2b respectively.

Group 1: Passive : 1a (J J Orthodontics)

1b (Damon-Ormco)

Group 2 : Active : 2a (Rabbit force Orthodontics)

2b (Orthomatix Orthodontics)

Each group comprised of 20 self-ligating pre-molar brackets each

ARMAMENTARIUM USED

- **BRACKET HOLDER**
- **EXPLORER**
- **SPIN TEK OPENING INSTRUMENT**
- **ACRYLIC BLOCKS**
- **GLUE**

Methods

In this in vitro study, opening force of each bracket clip was assumed to be the stiffness of the bracket. Opening force of each self-ligating bracket is calculated before and after 50 cycles of repetitive opening and closing movements. The comparison of these force indicates the change in stiffness.

The opening force of the self-ligating bracket is calculated with the help of a Universal testing machine.Each bracket was bonded to an acrylic block (5 brackets in a row). This acrylic block was then fixed in the lower jaw of an Instron Universal testing machine. An explorer was fixed to the upper part of the Universal testing machine. The edge of the explorer hook was inserted in the hole of the wicket of a closed bracket. The explorer hook was then moved upward in a vertical direction at a cross head speed of 1mm /min until the bracket was completely opened. Maximum opening force value (Newton) was recorded for each bracket before and after 50 cycles of repetitive opening and closure movements. All the readings were recorded in a tabular column during the experiment in the lab for each group separately.

FIGURE NO:1

ARMAMENTARIUM USED

FIGURE NO:2

ACTIVE SELF LIGATING BRACKETS (RABBIT FORCE ORTHODONTICS)

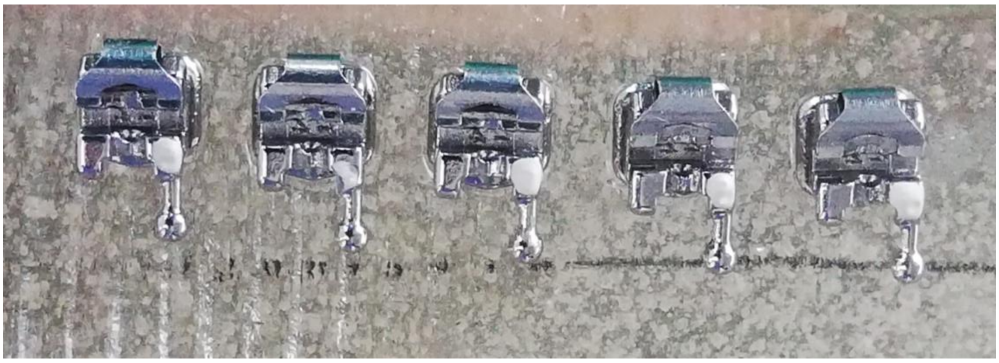


FIGURE NO:3

ACTIVE SELF LIGATING BRACKETS (ORTHOMATIX ORTHODONTICS)

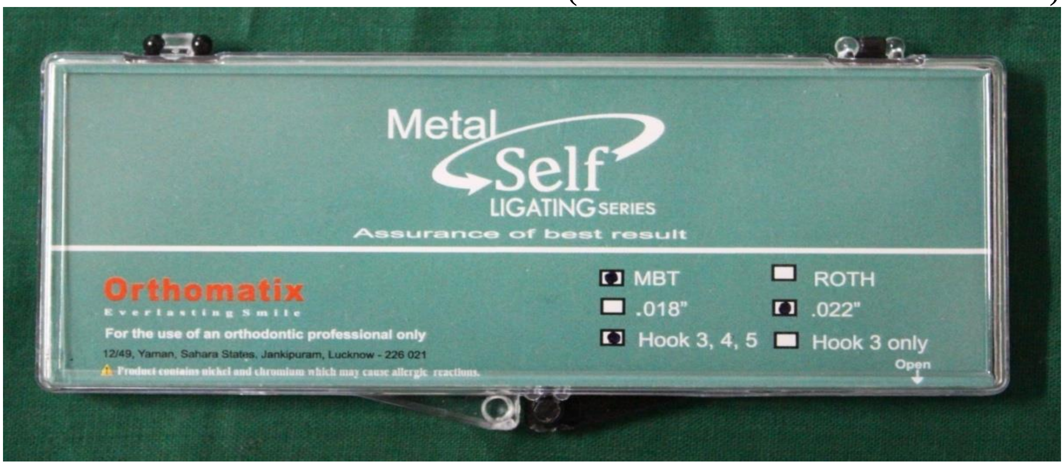


FIGURE NO: 4 PASSIVE SELF LIGATING BRACKETS (JJ ORTHODONTICS)

FIGURE NO:5 PASSIVE SELF LIGATING BRACKETS (DAMON 3mx)

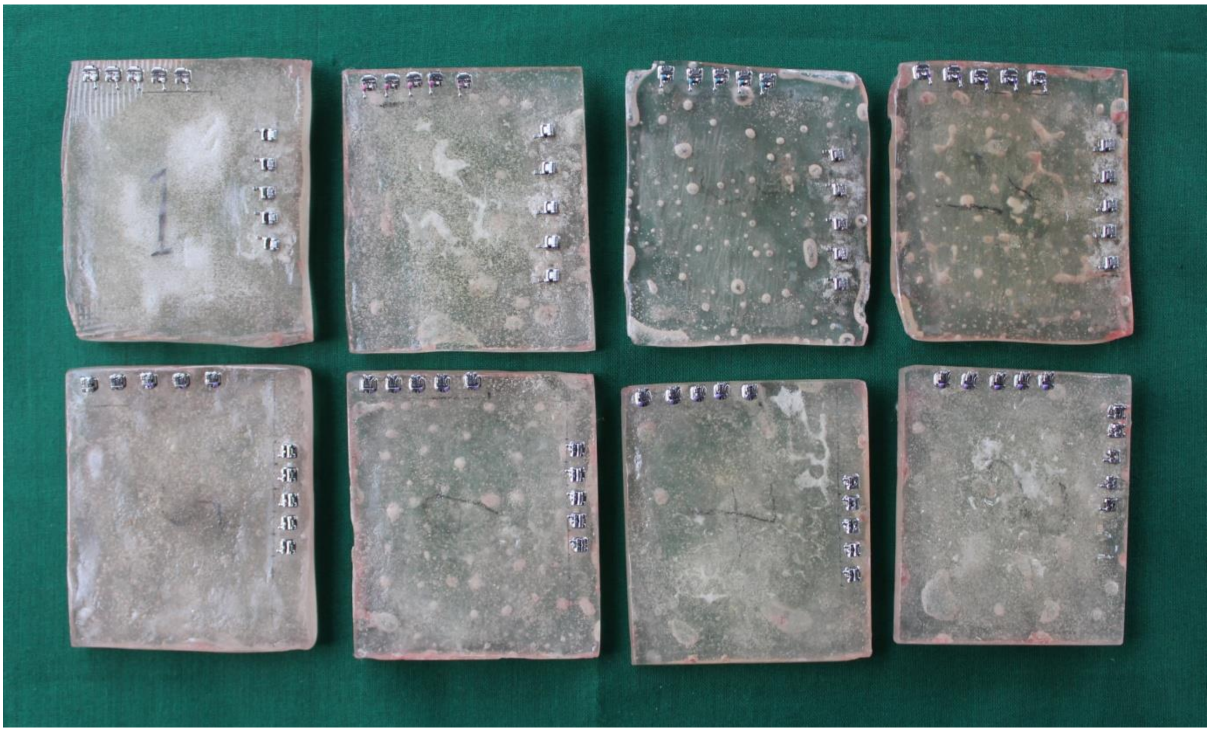
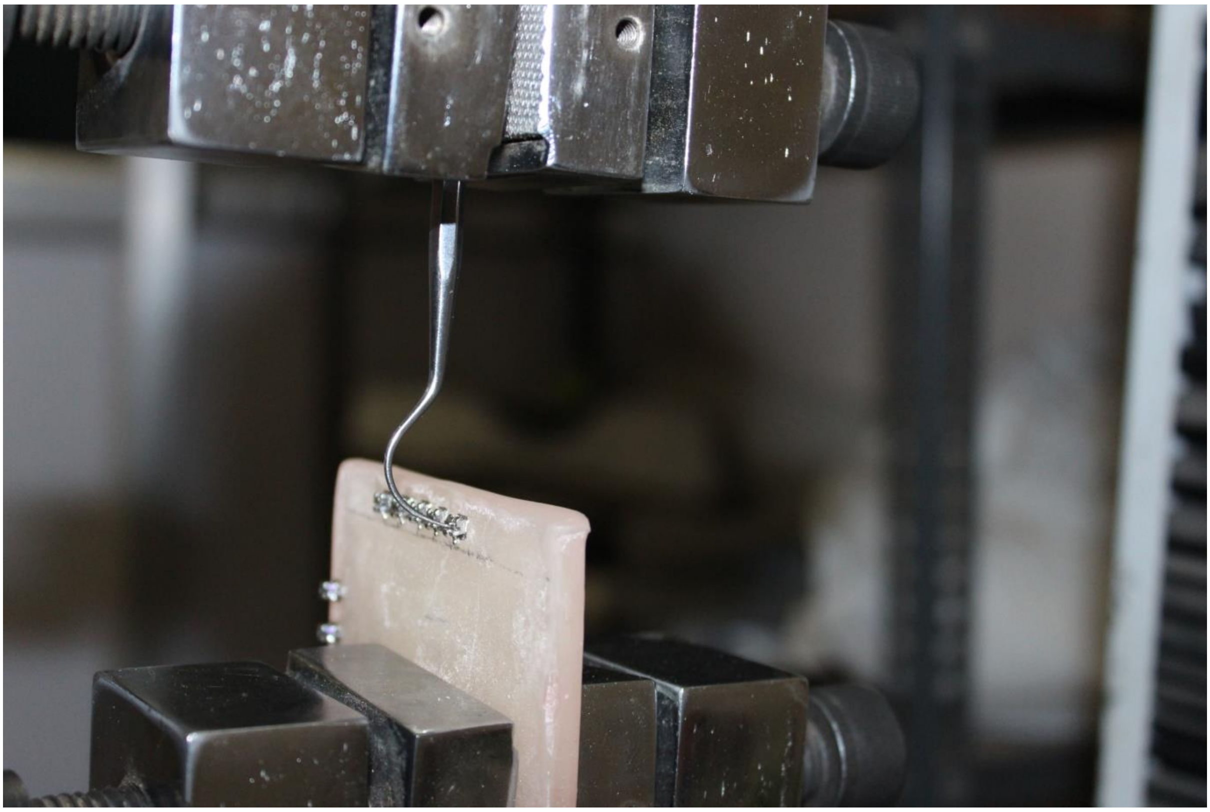


FIGURE NO: 6   TOTAL 80 SAMPLES (10 SAMPLES ARRANGED IN EACH BLOCK)

FIGURE NO: 7   KALPAK UNIVERSAL TESTING MACHINE

FIGURE NO: 8   UPPER AND LOWER JAW OF UNIVERSAL TESTING

MACHINE



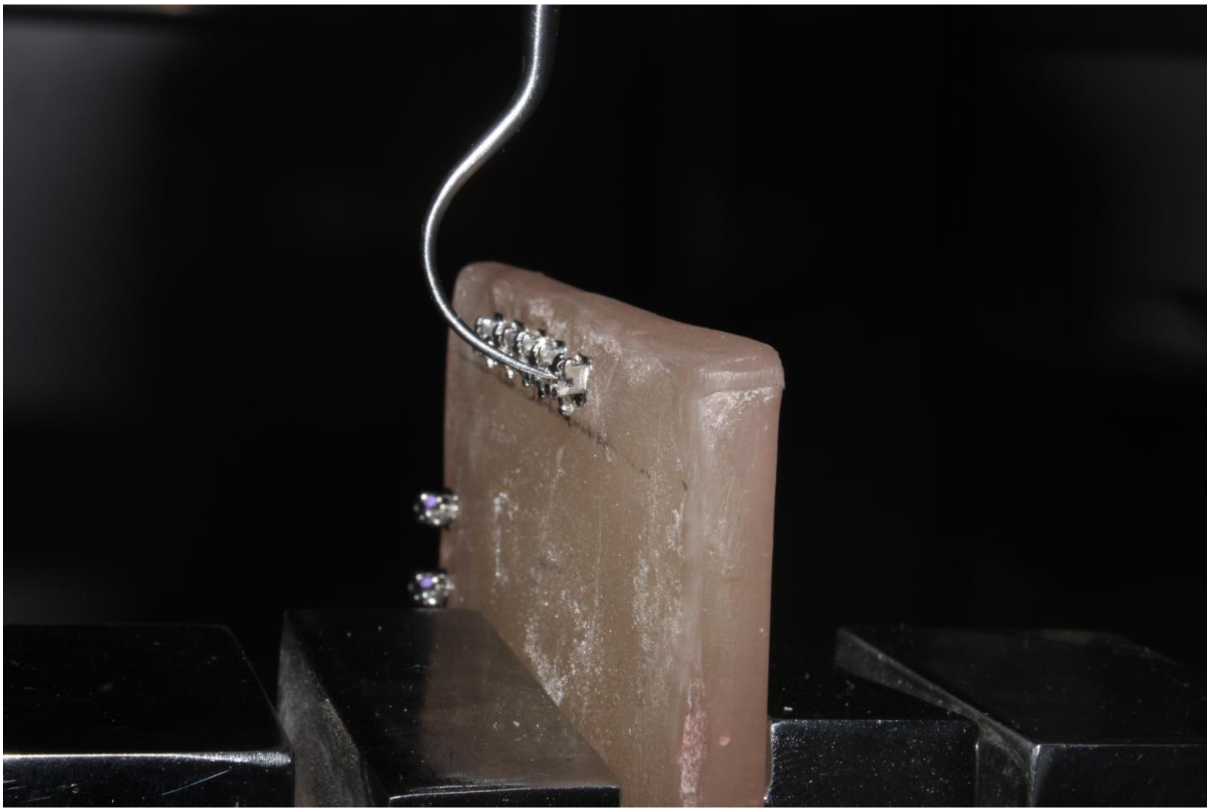


FIGURE NO: 9 EXPERIMENTAL SET UP

RESULTS & STATISTICAL ANALYSIS

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Date: 03.12.2018

PASSIVE SELF LIGATING BRACKETS

(JJ Orthodontics)

SAMPLE NUMBER	INITIAL OPENING FORCE (N)	FINAL OPENING FORCE after 50 cycles(N)
1.	9	9
2.	5	4
3.	7	7
4.	8	8
5.	9	8
6.	5	5
7.	6	6
8.	4	4
9.	6	5
10.	3	3
11.	7	6
12.	6	6
13.	7	7
14.	9	8
15.	6	4
16.	10	9
17.	8	4
18.	8	3
19.	9	8
20.	8	5

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PASSIVE SELF LIGATING BRACKETS

(ORMCO – DAMON Orthodontics)

SAMPLE NUMBER	INITIAL OPENING FORCE(N)	FINAL OPENING FORCE after 50 cycles(N)
1.	4	4
2.	4	4
3.	5	2
4.	2	2
5.	2	2
6.	5	4
7.	4	3
8.	4	3
9.	3	3
10.	4	4
11.	2	1
12.	5	5
13.	3	3
14.	2	2
15.	2	1
16.	6	5
17.	2	2
18.	3	3
19.	5	5
20.	4	4

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ACTIVE SELF LIGATING BRACKETS

(RABBIT FORCE ORTHODONTICS)

SAMPLE NUMBER	INITIAL OPENING FORCE(N)	FINAL OPENING FORCE after 50 cycles(N)
1.	17	14
2.	15	12
3.	14	12
4.	10	5
5.	11	5
6.	14	12
7.	14	11
8.	14	12
9.	15	14
10.	16	11
11.	10	9
12.	19	15
13.	4	3
14.	14	12
15.	15	13
16.	10	7
17.	8	6
18.	12	10
19.	10	8
20.	8	7

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Date: 03.12.2018

ACTIVE SELF LIGATING BRACKETS

(Orthomatix Orthodontics)

SAMPLE NUMBER	INITIAL OPENING FORCE(N)	FINAL OPENING FORCE after 50 cycles(N)
1.	14	7
2.	13	9
3.	10	9
4.	10	8
5.	15	7
6.	21	8
7.	18	16
8.	18	16
9.	8	7
10.	7	6
11.	22	11
12.	20	10
13.	17	10
14.	17	11
15.	21	8
16.	18	11
17.	19	9
18.	17	5
19.	16	7
20.	18	10

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STATISTICAL ANALYSIS

The mean and standard deviation were estimated for the four groups of samples.

To find out the significant difference between the groups , **students t-test** were used.

- The formula used to assess the **student's paired t-test** was

$$t = \bar{d}/SE(\bar{d})$$

Where

$SE(\bar{d})$ = Standarderror of d

$S/\sqrt{n} \sum n$

S = $\underline{i=1(d_i-\bar{d})^2}$

n-1

$\bar{d} = \sum n \ d_i$
$\underline{i=1}$
n

Where d_i is the difference of the observation at two time points.

P value less than 0.05 was considered to be statistically significant.

This test was done for group 1a and group 1b(between passive JJ brackets and passive Damon brackets)

- **Wilcoxon sign rank test**

This test was done among the group 2a and group 2b (active bracket groups) as there was a high variation among these groups.

The formula for Wilcoxon sign rank test is:

$$z = \frac{ws - n(n+1)/4}{\sqrt{\frac{n(n+1)(2n+1)}{24}}}$$

- **Anova Analysis**

The variability between the samples of four groups namely JJ brackets, Damon brackets, Rabbit force brackets and Orthomatix brackets were done by One way Anova analysis.

The formula used for the ANOVA analysis was

$$ANOVA = \frac{BMS - WMS}{BMS + (n-1)\,WMS}$$

Where

BMS = between subjects mean sum of squares

WMS = within subjects mean sum of squares

n = Number of measurements.

P value less than 0.05 was considered to be statistically significant

- **Chi –square test** is used to determine whether there is a significant difference between expected frequencies and observed frequencies in one or more categories.

$$x^2 = \frac{£(0-E)^2}{E}$$

x^2 = test statistic £= the sum of observed frequencies ‘O ‘ and expected frequencies ‘E’

Observed frequencies are the frequencies obtained from the observation, which are sample frequencies.The expected frequencies are the calculated frequencies

RESULTS:

Table 1: Student’s t test comparing two Passive Types of Brackets.

Types	N	Initial opening force (stiffness)		Final opening force(stiffness)		p-value
		Mean	SD	Mean	SD	
Passive JJ (group 1a)	20	7	1.86	5.95	1.95	0.0020
Passive Damon (group 1b)	20	3.5	1.28	3.1	1.25	0.0079

Inference: From the results obtained, there was a significant statistical difference between the Initial and Final Opening force(stiffness) of both types of Passive Brackets. ($p<0.05$).

Table 2: Wilcoxon sign rank test for two Active types of Brackets.

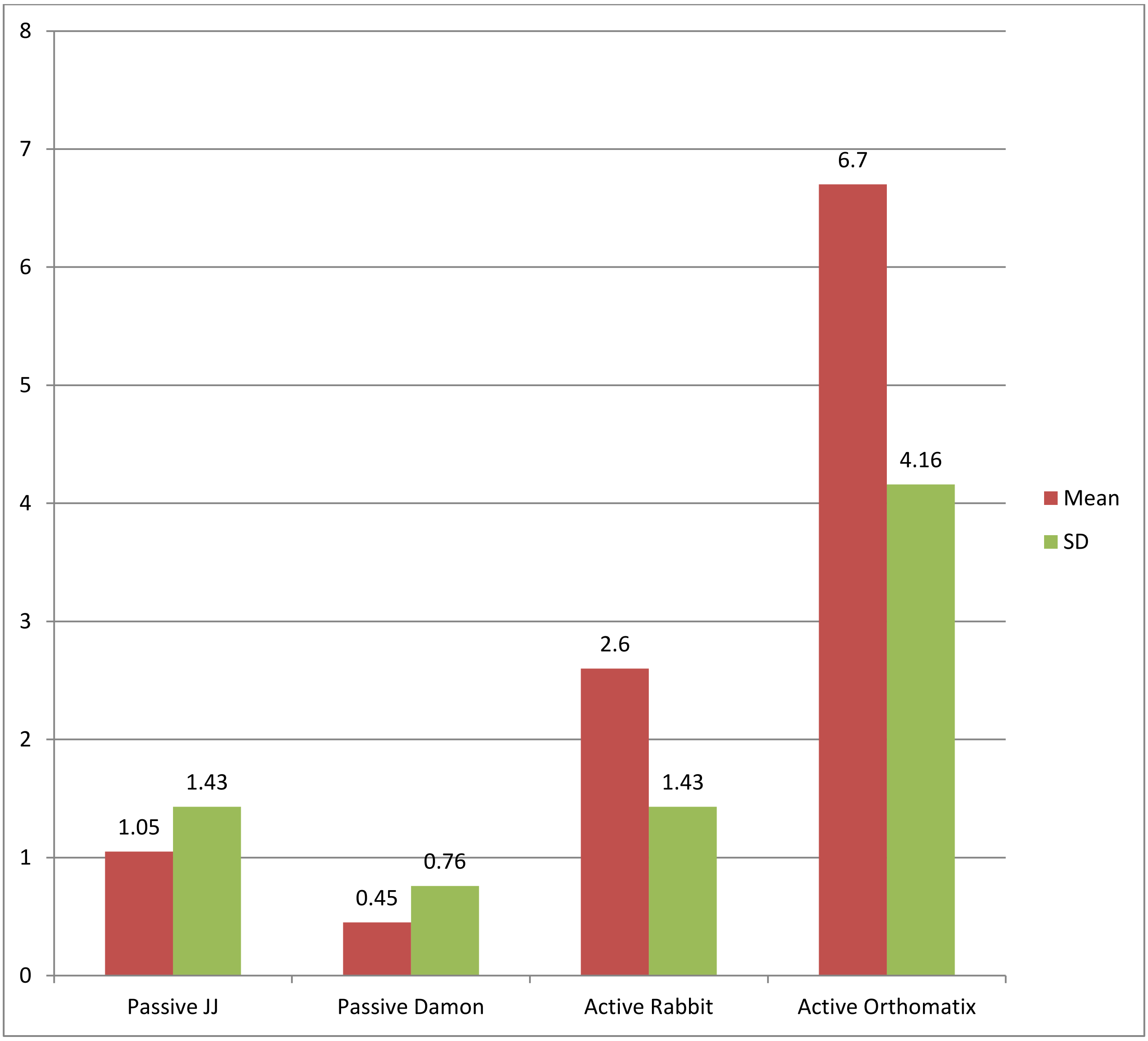
Types	n	Initial opening force(stiffness)		Final opening force(stiffness)		p-value
		Median	q1,q3	Median	q1,q3	
Active Rabbit (group 2a)	20	14	10, 15	11	7, 12	<0.001
Active Orthomatix (group 2b)	20	17	13.5, 18.5	9	7, 10.5	<0.001

Since the values obtained for two Active types of brackets had high variations among the Initial and Final Opening forces(stiffness), Wilcoxon Sign Rank test was assigned and the results were obtained as mentioned above.

Inference: From the results obtained, there was a significant statistical difference between the Initial and Final Opening force(stiffness) of both types of Active Brackets. (p<0.05).

Table 3: One-way ANOVA for comparing all four types of Brackets.

Types	N	Mean	SD	P-value
Passive JJ	20	1.05	1.43	<0.0001
Passive Damon	20	0.45	0.76	
Active Rabbit	20	2.6	1.43	
Active Orthomatix	20	6.7	4.16	

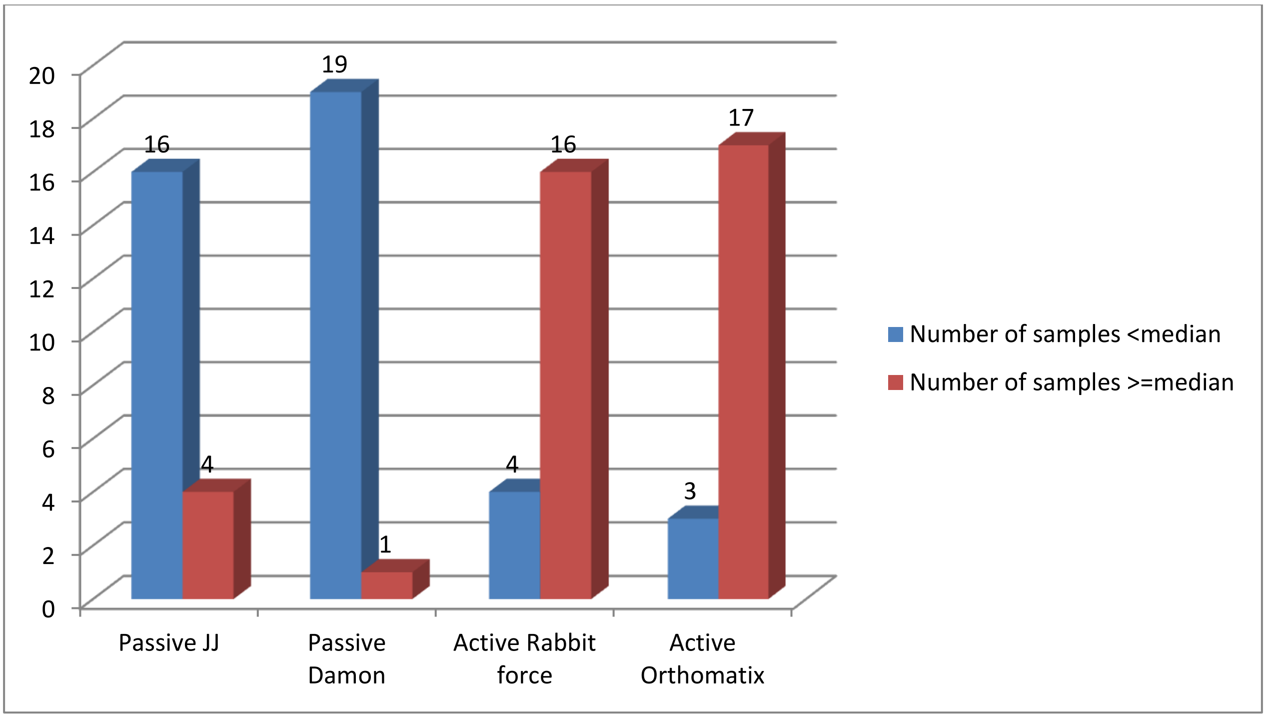


Inference: From the values obtained, there was significant statistical difference among four types of brackets.

From the values, it is inferred that Passive Damon brackets had low deflection(variation) between Initial and Final Opening Force followed by Passive JJ brackets, followed by Active Rabbit Force brackets and finally Active Orthomatix brackets.

Table 4: Chi-square Test performed within the types of brackets.

Types	Number of samples <median	In percentage	Number of samples >=median	In percentage	p-value
Passive JJ	16	80%	4	20%	<0.001
Passive Damon	19	95%	1	5%	
Active Rabbit force	4	20%	16	80%	
Active Orthomatix	3	15%	17	85%	



Inference: From the results obtained there was significant statistical difference among the four types of brackets groups.

1. It is inferred that 80% of Passive JJ type brackets had deflection values lower than that of its median value implying that(80% of brackets) it is clinically better even after 50 cycles of repeated usage.

2. It is inferred that 90% of Passive Damon type brackets had deflection values lower than that of its median value implying that(90% of brackets) it is clinically better even after 50 cycles of repeated usage.

3. It is inferred that 20% of Active Rabbit force type brackets had deflection values lower than that of its median value implying that(20% of brackets) it is clinically better even after 50 cycles of repeated usage.

4. It is inferred that 15% of Active Orthomatix type brackets had deflection values lower than that of its median value implying that(15%) it is clinically better even after 50 cycles of repeated usage.

DISCUSSION

DISCUSSION

The results shown in this study compared the stiffness and plastic deformation of clips of active and passive self ligating brackets (Active SLB's- Rabbit force orthodontics, orthomatix orthodontics and Passive SLB's JJ Orthodontics, Damon 3mx) . This study also showed how long these self ligating brackets withstood the continuous opening and closure movements and maintained the clip integrity with very mild loss of seating force or clip elasticity. Though stiffness had reduced slightly, this is enough for full arch wire engagement[71]. Brackets act as handles for the arch wire to transfer the force in any fixed appliance system. Hence the clips in the SLB's play an important role in engaging the arch wire securely. Force decay is the major problem in conventional brackets utilizing conventional ligation such as metallic and elastic modules. Such problems can be avoided in this system. An active clip can achieve early buccolingual alignment, even in smaller arch wire cross section and a better alignment than passive clip with the same cross section wire because the arch wire in the bracket slot of active self ligating brackets have less freedom of movement.[42]

Very few studies have been done about the stiffness or deformation of the clips in self ligating brackets. Ideally a clip should not undergo permanent deformation and must be rigid enough to hold the arch wire in the slot to produce the desired orthodontic force and at the same time it should be flexible enough to store energy.

Pandis et al[43] in another study evaluated the changes in stiffness of used self-ligating brackets and new self ligating brackets (SPEED brackets- speed system orthodontics, Cambridge, Ontario, Canada) in an orthodontic measurement and simulation system sensor (OMSS) .The basic question addressed in their study was pointed to the ability of clips of active self ligating brackets to exert a consistent force on the arch wires throughout the treatment but the design to study this parameter is biomechanically complex and this relies on the evaluation of stiffness of the clip and its variation with time. The choice of slope of the loading curve of each clip depends on its importance in modulating the mechanical response of a material under loading by changing its stiffness and also this variable is independent of specific bracket arch wire combinations as opposed to the force levels applied to the different dimensions of arch wires. Thus it facilities a method of estimating the force applied as a function of clip displacement. The results of their study suggests that clip of that both bracket were not plastically deformed. But the active clip of one bracket showed a significant aging effect resulting in a reduction of mean stiffness by more than 50%. Thus, performance and aging of the clips mainly depends on the alloy composition and the related phase transformations. In contrast to the other laboratory setup used to test friction by sliding of the wire on bracket slots, their experimental setup reliably simulated the forces developed during the tooth movement. They investigated the intrinsic property of the materials and did not depend on the manipulative components of the testing atmosphere when compared to the Universal testing machine setup so, although this study was a laboratory test, the result is not expected to differ in actual clinical conditions. They could not find any differences in the force exerted by the clip in SPEED brackets after 15 months of use. At the same time they found out extensive relaxation (reduction of almost 50 %) on this force over In- Ovation R brackets (Dentsply GAC International, Bohema, ,USA)

In the present study, it was found that there was no permanent deformation of clips for any 4 types of self-ligating brackets used, but it was found that there was a variation in stiffness reduction after 50 repetitive cycles of opening and closure movements. The results obtained were statistically analyzed . There was a statistically significant reduction in stiffness among 4 types of brackets used in this study. The whole experiment was conducted in a standard atmosphere and specific instruments were used for opening and closing. So during the orthodontic practice, clinicians might manage the clips in varying conditions such as arch wire/ clip interaction in severe crowding with arch wire deflection. Sometimes the use of different instruments causes damage to the clip. In some cases it may be due to greater forces applied during the opening and closing procedure[49]. Formation of hard calculus deposit around the brackets causes difficulty in opening and closing the clip and alters the stiffness ,deformation and breakage of the clip. So clinician should consider all these factors during the treatment.

Paola GANDHINI et al[49] evaluated the opening and closure forces of sliding mechanisms of different SLB's using Instron Universal Testing machine. They used Carrnere LX- ortho organizers; F1000,Leone; Damon-Q, Ormco) in their study. Opening forces were registered between 1.1 N and 5.6 N where as the closure forces were recorded between 1.57 N and 4.87 N. Significant differences were found among different brackets and between two prescriptions tested in their study. There is a variability in the force needed to open or close the bracket for each tooth in the same appliance type used. This may be due to the different bracket shape and size and also depends on the tooth position in the mouth, so clinician should consider this information when treating each patient. The evaluation of opening and closure forces needed to allow the sliding mechanism is essential because discomfort is a potential problem during fixed appliance orthodontic treatment due to this reason opening and closure forces should not exceed the normal in order to reduce discomfort in changing the arch wire or during the reactivation time. After the closure the wicket should remain locked until the next visit, leaving the wire engaged to the bracket slot and allowing the appliance to express the tooth movement. In some cases the presence of masticatory forces in deep bite cases, calculus formation around the bracket, make this mechanism difficult to open. All these factors might cause clip breakage and deformation.

Thomas W .Major et al[72] investigated third order torque in different types of self ligating brackets by analyzing the bracket's elastic and plastic deformations in conjunction with the expressed torque of varying angles of twist. As the wire is twisted relative to the bracket slot, stresses are produced in the wire and bracket and strain (deformation) of the wire or bracket will occur. In their study they concluded that In-ovation R had the least deformation due to the torquing of the three investigated bracket types. Damon-Q and SPEED on average had approximately 2.5 and 14 times greater maximum plastic deformation respectively than did In-ovation R .

Other factors which altered the stiffness variation may be caused by oxidation of material exposed to the oral environment for a long time. Theodore Eliades and Christoph Bourauel (2005)[71] analyzed the variety and potency of various aging variables affecting the morphology, structure and mechanical properties of polymeric and metallic orthodontic materials. They mentioned the force transferred from the activated arch wire to a pre-adjusted bracket slot, as well as friction during free sliding. They stated that the chance for aging on spring component of self ligating brackets adversely affect the ligation force while considering the intra oral environment. Further studies are needed on this topic before establishing the advantageous effects of self ligating brackets.

The long term intra oral exposure of orthodontic materials adversely affects the bond strength(aging of polymeric adhesives) as well as mechanotheraphy (friction variants, torque expressions, super elasticity and fracture)[71] . The evidence available from studies focused on the alterations of polymeric and metallic orthodontic materials that which conveys that mechanism of surface modification is non- specific. Firstly the precipitation of ion occurs followed by protein adsorption and formation of a biofilm which later calcifies. This is a normal finding in the retrieved materials regardless of composition structure, surface properties and application mode. The clinical consequence of intra orally produced alterations might vary depending on the individual requirements of each material application.

The aging of dental materials during the treatment adversely affect their properties and abilities. Surface characteristics, physical properties, compositions and mechanical properties were also found to be altered after the treatment[11]. Those arch wires which share common composition with clips of self ligating brackets required less number of cycles to fracture the NiTi wires. The properties of NiTi clips in SLB's in intra oral conditions are altered by 2 major factors ; there is a possibility of some phase transformation becoming partially irreversible[2] which adversely affect the load expression of activated clip. Second factor is the destruction of crystallographic structure found in long term applications caused by simultaneous action of a severe environment and a multi faceted loading style[11].

Other aspect of aging was reported in a study that evaluated the load exerted by NiTi wires during cooling and heating cycles[25]. Load at cooling was higher than that obtained during heating for the same increments. NiTi alloys when subjected to prolonged temperature fluctuations cannot sustain their original phase transformation properties. Each bracket respond differently depending on the alloy composition with varying processes. The clinical importance of these findings are relaxed clip might be incapable to apply forces due to aging, which could have been caused by the mechanical loading and environmental conditions. As a result wire might be inadequately engaged in to the bracket slot which might have an undesirable effect on the related mechanotherapeutical schemes.

The evaluation of result of these changes needs comparative clinical studies of the performance of these appliances.

The masticatory force and friction due to calculus deposits also may cause the reduction in the stiffness. The literature is less about the degradation of the clip during the orthodontic treatment. So more studies should be done on this topic. When correlating the Pandis et al[43] study results with the presented study results, the difference in this clip stiffness could be likely due to differences in the alloy composition and manufacturing process of these clips. Further research should be conducted to test other clinical features that might compromise the clip integrity.

“Elastic deformation” is material’s non permanent deformation produced by a load. “Plastic deformation” which produced at higher stresses than elastic deformation, is permanent deformation of the material. In the present study even after 50 cycles of repetitive opening and closure movements of the clip, there was no hindrance or breakage in the sliding mechanism or closing mechanism of the clip among all the four types of brackets used. Hence in the present study it was found that there was no plastic deformation for any of the bracket clip as none of the clip was brocken after 50 cycles of repetitive opening and closure movements. Grace Kelly Martins Carneiro et al[19] in a study concluded that there was significant changes in the stiffness of the clip among the various self-ligating brackets after repetitive opening and closure movements. But repetitive opening and closure movements of the clip did not cause plastic deformation. The above conclusion is in agreement with our present study done in the other brands of self-ligating brackets.

Limitations of this study are that all the investigations has been conducted under ideal laboratory conditions, where as in oral cavity the factors like saliva, calculus, corrosion and other variables can influence the wicket sliding movements[58]. And also factors like masticatory forces, position of the tooth, forces exerted by torqued arch wires, type of diet were not included. If all these factors are included, more variation in stiffness might be observed. Moreover, clinical experience shows that a mechanistic view of self ligating brackets is misleading. Among other things, orthodontics deals with science, evidence, psycho-social issues, a record taking, diagnosis, treatment, outcomes, artistry, enhancements, quality of life issues. The findings of the present study ,within their limits suggests more researches are needed in order to analyze all variables and quantify and apprise the original influence of opening and closing forces of clips on clinical use of various self -ligating brackets available. Further studies are recommended for comparing clips of similar brands of active and passive self-ligating brackets under in vivo conditions.

SUMMARY & CONCLUSION

SUMMARY AND CONCLUSION

SUMMARY

This in vitro study evaluated and compared the stiffness and plastic deformation of clips of four different self-ligating brackets after 50 cycles of repetitive opening and closure movements in a standardized controlled test. Significant stiffness reduction was evaluated among 4 different self-ligating bracket types such as JJ brackets , Damon brackets, Rabbit force brackets and Orthomatix brackets. There was no significant change in plastic deformation because none of the brackets among the 80 samples used for the experiment were plastically deformed as there was no clip breakage even after 50 cycles of repetitive opening and closure movements.

Significant stiffness reduction of the bracket clips was found between two passive type of SLB's (JJ and DAMON brackets).Among these two types, it was observed that there was more stiffness reduction in JJ bracket clip when compared to Damon bracket clip. Significant stiffness reduction of the bracket clip was also found between two active type of SLB's (Rabbit force brackets and Orthomatix brackets). Among these two types, it was observed that there was more stiffness reduction in active orthomatix bracket clip when compared with Rabbit force bracket clips. From the limited sample result, it was found that Passive Damon bracket clips had the lowest stiffness reduction followed by Passive JJ bracket clips, followed by Active Rabbit force bracket clips and finally Active Orthomatix bracket clips. Among the Passive JJ brackets, 80% of bracket clips were clinically better even after 50 cycles of

repetitive opening and closure movements. Among the Passive Damon brackets , 90% of bracket clips were clinically better even after 50 cycles of repetitive opening and closure movements. Among the Active Rabbit force brackets , 20 % bracket clips were clinically better even after 50 cycles of repetitive opening and closure movements. Among the Orthomatix brackets, 15% of bracket clips were clinically better even after 50 cycles of repetitive opening and closure movements.

CONCLUSION

- A significant reduction in stiffness of the bracket clips were found among 4 different types of self-ligating brackets used in this study.
- More reduction in the stiffness of bracket clips were observed in active self-ligating brackets used in this study.
- There was no clip breakage (plastic deformation) after 50 cycles of repetitive opening and closure movements among 4 types of self-ligating brackets used in this study.

.

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BIBILOGRAPHY

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ANNEXURES

INSTITUTIONAL ETHICAL COMMITTEE

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Ref.: 151/KSRIDSR/EC/2016 **Date : 19.12.2016**

To

Dr.K.T.Unais,
Postgraduate Student,
Dept. of Orthodontics,
KSR Institute of Dental Science & Research,

*****

Your dissertational study titled "EVALUATION OF STIFFNESS AND PLASTIC DEFORMATION OF DIFFERENT CLIPS/SPRINGS OF SELF LIGATING BRACKETS AFTER REPETITIVE OPENING AND CLOSURE MOVEMENTS" presented before the ethical committee on 16th Dec. 2016 has been discussed by the committee members and has been approved.

You are requested to adhere to the ICMR guidelines on Biomedical Research and follow good clinical practice. You are requested to inform the progress of work from time to time and submit a final report on the completion of study.

Signature of Member Secretary
(Dr.G.S.Kumar)

URKUND

Urkund Analysis Result

Analysed Document: for plagiariasm.docx (D46298020)
Submitted: 12/28/2018 5:14:00 AM
Submitted By: unaisbds@gmail.com
Significance: 21 %

Sources included in the report:

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CERTIFICATE - □

This is to certify that this dissertation work titled "EVALUATION OF STIFFNESS AND PLASTIC DEFORMATION OF DIFFERENT CLIPS/SPRINGS OF SELFLIGATING BRACKETS AFTER REPETITIVE OPENING AND CLOSURE MOVEMENTS" of the Candidate Dr.Unais K.T with registration number 241619253 for the award of" Master of Dental Surgery" in the branch of Orthodontics and Dentofacial Orthodontics. I personally verified the urkund.com website for the purpose of plagiarism check. I found that the uploaded thesis file contains from the introduction to conclusion pages and results shows and results show 21% of plagiarism in the dissertation.

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