Research Article

JRAD Journal of Research and Advancement in Dentistry

J Res Adv Dent 2016;5:1:232-238.

Comparison of the Frictional Resistance of Ceramic Self Ligating Brackets and Conventional Ceramic Brackets: An in Vitro Study

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ABSTRACT

Aim: The aim of this study was to evaluate and compare the static and kinetic friction in ceramic brackets when used with Teflon coated arch wires and esthetic ligatures/coated transparent elastomeric modules as compared to ceramic self-ligating brackets.

Materials and methods: Four types of brackets namely a) Conventional ceramic bracket with metal slot b) Conventional ceramic bracket without metal slot c) Passive Self ligating ceramic bracket with metal slot and d) Passive Self ligating ceramic bracket without metal slot were evaluated when used with Teflon coated wires of dimension (0.018" NiTi, 0.017x0.025" NiTi, 0.019x0.025" SS wires). In conventional brackets super Slick Mini Stik modules and Teflon coated stainless steel ligatures were used. Data relating to sample of 120 brackets was analysed using One-way ANOVA and Post hoc Tukey Test.

Results: With 0.018 NiTi" and 0.019x0.025" SS wires, self-ligating brackets with metal slots showed the least friction and with 0.017x0.025" NiTi wires conventional ceramic brackets with metal slots when ligated with coated modules showed the least friction.

Conclusion: Self ligating brackets showed least friction except with 0.017x0.025" wires. Conventional ceramic brackets with metal slots displayed less friction when ligated with Super Slick Mini Stik modules where as those without metal slots displayed less friction when ligated with Teflon coated ligatures. Ceramic brackets without metal slots showed the highest friction and the presence of the stainless steel slot played a major role in determining friction.

Keywords: Self ligating brackets, Ceramic brackets, Friction, Teflon coated ligatures and Super Slick Mini Stik modules.

INTRODUCTION

Rapid advances in science and technology and its application to clinical practice has improved the armamentarium and revolutionized the science of Orthodontics. However, one problem that the orthodontist still has to deal with is friction. Sliding a tooth along an arch wire is still very much standard practice and the role of friction is well appreciated by the orthodontist [1]. Despite attempts at efficient treatment mechanics, not all the force delivered on the teeth is utilized since it has been reported that as much as 12 – 60% is lost due to friction[2] and this affects the treatment efficiency and prolongs treatment duration[3].

Received: May. 18, 2015: **Accepted:** Oct. 11, 2015
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pISSN 2278-0076
eISSN 2321-9270

As the friction increases, more force has to be applied to achieve the desired tooth movement. This in turn taxes the anchorage[4,5] and challenges patient tolerance[5,6], other than the possibility of causing direct tissue damage. The factors influencing the friction are wire alloy composition, wire deflection, wire size, bracket slot material, bracket width, lubrication and method of ligation[7]. Of the wires commonly used, it has been well established that the stainless steel wires produce the least friction, followed by nickel titanium alloys and beta titanium alloys[8,9,10].

Although stainless steel brackets display significantly less frictional resistance than most brackets available, the emphasis on esthetics has lead to a plethora of tooth colored brackets in the market. Of these, the ceramic brackets are most popular because of their translucency, superior esthetics, stain resistance and ultra smoothness. However the major disadvantage of ceramic brackets is friction leading up to 60% of force loss[11].

An attempt to overcome this are ceramic brackets with stainless steel slots which demonstrate less friction than conventional ceramic brackets however more than stainless steel brackets[11,12]. Another important contributor to frictional resistance is the ligation method since friction increases with ligation force[13]. It has been demonstrated that 31– 54% of the total frictional force generated by a premolar bracket when 0.019x0.025SS wire was inserted was due to the friction of ligation and 46-69% to elastic binding[14]. Attempts to reduce friction have resulted inlubricated elastomeric ligatures[15] ,polymeric coated modules[16], 45 degree angulated ligatures[17] and Teflon coated ligatures [18].

Recent entries to the field of orthodontics are the self ligating brackets (SLB). These brackets have become popular in the past decade because of various advantages claimed over the conventional ligation method[19]. Among the numerous advantages, they have demonstrated reduced friction as compared to conventional brackets [13,20,21]. To meet the esthetic demands, the self ligating brackets have also been introduced in ceramic which are also available with stainless steel metal slots.

Teflon coated wires are also widely used with esthetic brackets. With such a wide range of esthetic options available it is important to evaluate which one of these might produce acceptable levels of friction. Although several studies have evaluated and compared the friction of ceramic brackets to stainless steel brackets, very few studies have compared esthetic self-ligating brackets to conventional ceramic brackets. Furthermore, no study to the best of our knowledge have evaluated friction in ceramic brackets when used exclusively with Teflon coated archwires and esthetic modes of ligation.

Thus the aim of this was to

1) Evaluate and compare the static and kinetic friction generated in ceramic brackets with and without stainless steel slots when used with Teflon coated

archwires and ligated with teflon coated ligatures and coated transparent elastomeric modules

2) To compare the above to ceramic self ligating brackets with and without stainless steel slots.

MATERIALS AND METHODS

Four types of brackets were chosen for this study.

1. Conventional ceramic bracket with metal slot. (3M Unitek - Clarity™ metal reinforced ceramic brackets).
2. Conventional ceramic bracket without metal slot. (Ormco - Inspire brackets).
3. Passive Self ligating ceramic bracket with metal slot. (3M Unitek - Clarity™ SL brackets).
4. Passive Self ligating ceramic bracket without metal slot. (Ormco - Damon Clear brackets).

All the brackets were upper right first premolar of 0.022” x 0.028” slot size.

The ligatures used in this study were Super Slick Mini Stik modules (T.P. Orthodontics) and Teflon coated stainless steel ligatures (Rabbit force��USA). The Super Slick Mini Stik modules are coated elastomeric modules. The wires used for this study were preformed 0 .018” NiTi, 0 .017x0.025” NiTi, 0.019x0.025” SS wires (Ortho - direct Farmingbale NY). All three wires were Teflon coated.

One hundred and twenty brackets were included in this study and these were subdivided into 6 groups (Table I) The static and the kinetic frictional values were tested using an INSTRON machine at the Central Leather Research Institute (CLRI) in Guindy, Chennai. The load cell used for this study was 100 N load cell. The Instron machine has two jaws namely the upper and the lower jaws. The lower jaw of the testing machine is fixed and the upper jaw can be displaced. The distance between the jaws was kept fixed at 6cm. An acrylic block of 8 X 3 cm was taken and a line was drawn dividing the block into two halves of 4 X 3 cm each. The lower end of the block was attached to the lower jaw of the testing machine. On the upper half, two lines were drawn (one horizontal and another vertical) intersecting each other at the center. Each bracket was bonded to an individual block at the point of intersection of these two lines. The bonding of the bracket to the acrylic block was done using an industrial adhesive (Anabond 555).

The segment of the preformed arch wire chosen for testing was the most straight portion of the arch wire. The length of the wire was 4 cm. For Group 2 and Group 5, the wires were ligated to the brackets using the Teflon coated ligatures as suggested by Bazakidou et al[22]. For all groups, after the wire was engaged in the bracket slot the samples were fixed onto the testing machine. The lower end of the wire was kept free and the upper end of the wire was attached to the upper jaw.

The friction tests were done in the dry state. The crosshead speed of the machine was set at 10mm / min. The testing was initiated by keeping a constant load of 100 N and based on the displacement of the wire, static and kinetic frictions were measured. The load Vs displacement graphs were obtained (Fig. 1). The friction was calculated in Newtons. Both static and kinetic frictions were measured. Static friction was measured as the peak load at which the movement was initiated and the kinetic friction was measured as the mean force required for maintaining the movement. For measuring kinetic friction, values were taken at every 2mm intervals of displacement during the experiment and the mean value was calculated. Each sample was run five times and the mean value was recorded.

STATISTICAL ANALYSIS

Mean and standard deviations were calculated from the readings of static and kinetic frictions using SPSS software. One way ANOVA test was used to analyse the differences among the groups (Table 2 and 3). Post hoc Tukey test was used to identify the statistical significance between the groups and wire dimensions (Table 4, 5 and 6).

RESULTS

0.018” NiTi

For both static and kinetic frictions group 4 showed the least friction followed by group 1, group 5, group 6, group 2 and group 3.

For 0.017 x 0.025” NiTi

For both static and kinetic frictions, group 6 showed the least friction followed by group 5, group 4, group 1, group 2 and group 3.

For 0.019 x 0.025” SS

For both static and kinetic frictions, group 4 showed the least friction followed by group 6, group 5, group 1, group 2 and group 3.

DISCUSSION

Esthetic appliances have gained popularity over the last few decades more so because the patient’s demographics have changed to include more adults seeking orthodontic treatment. Although several esthetic options are available, the ceramic brackets still continue to be popular because of their superior esthetic properties.

Friction plays an important role in the final outcome of treatment. Various methods have been employed to reduce friction and to alter the wire bracket interface. Brackets have been modified by altering the bracket width[13,23], bracket slot configuration24and material[22,25,26]. A recent advancement has been the self ligating brackets which have proved efficient in reducing friction[27].

Ligatures have also been modified to reduce friction[16,17,18,28] . The reduction in friction is mainly achieved by coating over the surfaces of the ligatures. E.g: Teflon coated stainless steel ligatures[18] and coated elastomeric modules such as

Super Slick modules[16,28], Slide ligatures[29,30] and Super-Slick Mini Stik ligatures[17]. Our study focused on evaluating friction in various esthetic bracket – arch wire – ligation combinations. The results of our study showed that ceramic self ligating brackets with metal slots showed the least static and kinetic frictional resistance with all wires except 0.017x0.025" NiTi wires. With 0.017x0.025" NiTi wires conventional ceramic brackets with metal slots showed the least friction followed by SLB with metal slots. For 0.018 wires both SLB brackets showed less friction than conventional brackets with metal slots. However for 0.019x0.0025 stainless steel wires conventional ceramic brackets with metal slots displayed less friction than SLB without metal slots.

Comparison between the two ceramic self ligating brackets showed that the one with metal slot showed less friction than that without in all testing conditions. It must be remembered that there is a fourth wall in SLBs without metal slots. In case of Damon Clear brackets, the fourth wall of the bracket is made up of ceramic. This was found to play a major role in determining friction as ceramics have rougher surfaces than metals [10,12,25]. When used with NiTi, even Clarity SL bracket displayed more friction. This could be attributed to the fact that in this bracket, the fourth wall is a NiTi clip which holds the wire in place. Hence the increased friction could probably be due to the contact between NiTi wire and the NiTi clip inherent to the bracket.

In all testing conditions conventional ceramic brackets without metal slots showed the highest friction. This was in accordance with other studies where ceramic brackets without metal slots have proved to show increased frictional resistance[7,11,12].

In our study we used only coated modules because it has been established that coated modules display less friction than uncoated modules[16,17,28]. In conventional ceramic brackets with metal slots, Super Slick Mini Stik modules showed less static and kinetic friction when compared to Teflon coated ligatures (Table 2 and 3) except for 0.018 wires.

However a previous study which evaluated the frictional resistance between the Teflon coated ligatures and Super Slick Mini Stik modules on metal brackets showed that Teflon coated ligatures produced less friction than the coated elastomeric ligatures[31]. This was true for all wires. De Franco (1995) documented that the lower friction values were attributed to the Teflon material possessing a lower coefficient of friction than elastomeric ligatures. The lower friction has also been attributed to the fact that Teflon coated ligatures generated lighter forces of engagement of the arch wire to the bracket slot than the elastomeric modules[18] .This pattern was exhibited in our study by ceramic brackets without metal slots where reduced static and kinetic frictions were shown by Teflon coated ligatures as compared to Super Slick Mini Stik modules.

A number of studies have emphasized the role of wire dimensions and alloys on friction. In our study, of all the three wires used, the least friction was displayed by round wire[10,13,21]. The role of alloys is also well established in the literature and it was earlier proved that NiTi wires demonstrated greater friction than the stainless steel wire[1,8,9,10,25]. In our study, when 0.017x0.025" NiTi and 0.019x0.025" SS were compared, 0.017x0.025" NiTi showed more static and kinetic frictions under all testing conditions (Table 2 and 3). Inspite of its lower wire dimension, thus emphasizing the role of the alloy in determining the amount of friction generated.

Previous studies have compared esthetic brackets with metal slots and ceramic interactive SLB's and found that ceramic interactive SLB's showed the least frictional resistance[32]. The results of our study cannot be directly compared to other studies because this is the first study to our knowledge where all the variables are restricted to esthetic options. Furthermore the SLB's used in this study were both passive. Further in vivo studies might better confirm the findings of our study and facilitate the choice from a wide array of esthetic options.

CONCLUSION

1) Self ligating brackets with metal slots showed the least static and kinetic frictions with all wires (except with 0.017 x 0.025" NiTi wires)

2) With 0.017 x 0.025” NiTi wire s, conventional ceramic brackets with metal slots displayed least friction.

3) Conventional ceramic brackets with metal slots also displayed less static and kinetic frictions than self ligating bracket without metal slot (except with 0.018” NiTi)

4) Self ligating brackets with and without metal slots displayed less friction than conventional ceramic brackets without metal slots.

5) SLB brackets with metal slots displayed less friction than SLB without metal slots.

6) Conventional brackets with metal slots showed less friction than conventional brackets without metal slots.

7) Conventional ceramic brackets with metal slots displayed less static and kinetic frictions when ligated with Super Slick Mini Stik modules (except with 0.018” NiTi where Teflon coated ligatures showed less friction)

8) Conventional ceramic brackets wi thout metal slots displayed less static and kinetic frictions when used with Teflon coated ligatures.

Although SLB’s with metal slots were superior to all brackets in almost all testing condition, conventional brackets with metal slots however displayed comparable efficiency and were in fact best for use with NiTi wires. So either bracket with metal slots could be chosen by the discerning clinician. The decision to use ceramic self ligating brackets to control friction can at best be advocated in the larger context of their other merits.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

REFERENCES

1. Stannard JG, Gau JM, Hanna MA. Comparative friction of orthodontic wires under dry and wet conditions. Am J Orthod. 1986;89(6):485-91.
2. Hain M, Dhopatkar A, Rock P. A comparison of different ligation methods on friction. Am J Orthod Dentofacial Orthop. 2006;130(5):666-70.
3. Hamdan A, Rock P. The effect of different combinations of tip and torque on archwire/bracket friction. Eur J Orthod. 2008;30(5):508-14.
4. Budd S, Daskalogiannakis J, Tompson BD. A study of the frictional characteristics of four commercially available self-ligating bracket systems. Eur J Orthod. 2008;30(6):645-53.
5. Nanda R. Biomechanics and Esthetic Strategies in Clinical Orthodontics Elsevier Saunders; 2005.
6. Tecco S, D'Attilio M, Tete S, Festa F. Prevalence and type of pain during conventional and self-ligating orthodontic treatment. Eur J Orthod. 2009;31(4):380-4.
7. Griffiths HS, Sherriff M, Ireland AJ. Resistance to sliding with 3 types of elastomeric modules. Am J Orthod Dentofacial Orthop. 2005;127(6):670-5.
8. Tidy DC. Frictional forces in fixed appliances. Am J Orthod Dentofacial Orthop. 1989;96(3):249-54.
9. Kusy RP, Whitley JQ. Coefficients of friction for arch wires in stainless steel and polycrystalline alumina bracket slots. I. The dry state. Am J Orthod Dentofacial Orthop. 1990;98(4):300-12.
10. Angolkar PV, Kapila S, Duncanson MG, Jr., Nanda RS. Evaluation of friction between ceramic brackets and orthodontic wires of four alloys. Am J Orthod Dentofacial Orthop. 1990;98(6):499-506.
11. Guerrero AP, Guariza Filho O, Tanaka O, Camargo ES, Vieira S. Evaluation of frictional forces between ceramic brackets and archwires of different alloys compared with metal brackets. Braz Oral Res. 2010;24(1):40-5.
12. Cacciafesta V, Sfondrini MF, Scribante A, Klersy C, Auricchio F. Evaluation of friction of conventional and metal-insert ceramic

brackets in various bracket-archwire combinations. Am J Orthod Dentofacial Orthop. 2003;124(4):403-9.

13. Frank CA, Nikolai RJ. A comparative study of frictional resistances between orthodontic bracket and arch wire. Am J Orthod. 1980;78(6):593-609.

14. Iwasaki LR, Beatty MW, Randall CJ, Nickel JC. Clinical ligation forces and intraoral friction during sliding on a stainless steel archwire. Am J Orthod Dentofacial Orthop. 2003;123(4):408-15.

15. Chimenti C, Franchi L, Di Giuseppe MG, Lucci M. Friction of orthodontic elastomeric ligatures with different dimensions. Angle Orthod. 2005;75(3):421-5.

16. Leander D, Kumar JK. Comparative evaluation of frictional characteristics of coated low friction ligatures - Super Slick Ties with conventional uncoated ligatures. Indian J Dent Res. 2011;22(1):90-4.

17. De Franco DJ, Spiller RE, Jr., von Fraunhofer JA. Frictional resistances using Teflon-coated ligatures with various bracket-archwire combinations. Angle Orthod. 1995;65(1):63-72.

18. Chen SS, Greenlee GM, Kim JE, Smith CL, Huang GJ. Systematic review of self-ligating brackets. Am J Orthod Dentofacial Orthop. 2010;137(6):726 e1- e18.

19. Pizzoni L, Ravnholt G, Melsen B. Frictional forces related to self-ligating brackets. Eur J Orthod. 1998;20(3):283-91.

20. Thomas S, Sherriff M, Birnie D. A comparative in vitro study of the frictional characteristics of two types of self-ligating brackets and two types of pre-adjusted edgewise brackets tied with elastomeric ligatures. Eur J Orthod. 1998;20(5):589-96.

21. Bazakidou E, Nanda RS, Duncanson MG, Jr., Sinha P. Evaluation of frictional resistance in esthetic brackets. Am J Orthod Dentofacial Orthop. 1997;112(2):138-44.

22. Kapila S, Angolkar PV, Duncanson MG, Jr., Nanda RS. Evaluation of friction between edgewise stainless steel brackets and orthodontic wires of four alloys. Am J Orthod Dentofacial Orthop. 1990;98(2):117-26.

23. Thorstenson GA, Kusy RP. Effects of ligation type and method on the resistance to sliding of novel orthodontic brackets with second-order angulation in the dry and wet states. Angle Orthod. 2003;73(4):418-30.

24. Pratten DH, Popli K, Germane N, Gunsolley JC. Frictional resistance of ceramic and stainless steel orthodontic brackets. Am J Orthod Dentofacial Orthop. 1990;98(5):398-403.

25. Tselepis M, Brockhurst P, West VC. The dynamic frictional resistance between orthodontic brackets and arch wires. Am J Orthod Dentofacial Orthop. 1994;106(2):131-8.

26. Tecco S, Di Lorio D, Nucera R, Di Bisceglia B, Cordasco G, Festa F.Evaluation of the friction of self ligation and conventional bracket systems. Eur J Orthod. 2011;5:310-317.

27. Hain M, Dhopatkar A, Rock P. The effect of ligation method on friction in sliding mechanics. Am J Orthod Dentofacial Orthop. 2003;123(4):416-22.

28. Arun AV, Vaz AC. Frictional characteristics of the newer orthodontic elastomeric ligatures. Indian J Dent Res. 2011;22(1):95-9.

29. Baccetti T, Franchi L. Friction produced by types of elastomeric ligatures in treatment mechanics with the preadjusted appliance. Angle Orthod.2006;76(2):211-6.

30. Tecco S, Di Iorio D, Cordasco G, Verrocchi I, Festa F. An in vitro investigation of the influence of self-ligating brackets, low friction ligatures, and archwire on frictional resistance. Eur J Orthod. 2007;29(4):390-7.

31. Bortoly TG, Guerrero AP, Rached RN, Tanaka O, Guariza-Filho O, Rosa EA. Sliding resistance with esthetic ligatures: an in-vitro study. Am J Orthod Dentofacial Orthop. 2008;133(3):340 e1-7.

32. Voudouris JC, Schismenos C, Lackovic K, Kuftinec MM. Self-ligation esthetic brackets with low frictional resistance. Angle Orthod. 2010;80(1):188-94.