SJIF IMPACT FACTOR: 4.402 CRDEEP Journals
International Journal of Life Sciences Mohammed Ahmed Salim Vol. 3 No. 4 ISSN: 2277-193x
International Journal of Life Sciences. Vol. 3 No. 4. 2014. Pp. 251-255

Full Length Research Paper

A Comparative study of Resistance during Tooth Retraction Using Ceramic Bracket and Ceramic Bracket with Metal Slot: In-Vitro Study

Mohamed Ahmed Salim
Orthodontics Department, Faculty of Dentist, Al-Azhar University, Assuit Branch Egypt.

Abstract
Frictional resistance is an important counterforce to orthodontic tooth movement during sliding mechanics. This study was carried out to evaluate the effect of ceramic bracket and ceramic bracket with metal slot -archwire- ligation combinations on "resistance to sliding" during simulated canine retraction on typodont model. The frictional resistance was tested between Ceramic brackets (3MUNITEK Clarity ADVANCED, Monrovia, CA) and Ceramic brackets with metal slot (3 MUNITEK METAL REINFORCED, Monrovia, CA). Eleven different rectangular archwires of 0.016 × 0.022 inch were used in the study as follows: Stainless steel and NiTi (Both archwires from Ortho Organizers, San Marcos, CA), three labial coated rectangular archwires: Stainless steel (Noninium White, DENTAURUM, Ispringen, Germany), NiTi (Rematitan LITE,DENTAURUM, Ispringen, Germany) and thermoactive NiTi (Tensic White, DENTAURUM, Ispringen, Germany), five full coated archwires: Stainless steel and NiTi (Tooth Tone Archwires, ORTHO TECHNOLOGY, Tampa, Florida, USA), Stainless steel and NiTi (Ultresthetic Tooth Colored Archwires, G&H ORTHODONTICS, Greenwood, Indiana, USA) and NiTi (Memoria Natura Preformed Archwires, LEONEAMERICA, Oxnard, CA) and Rhodium coated (Memoria Mimetic with Rhodium coating, LEONE S. P. A, Italy). The Ligation materials used were: Stainless steel ligature 0.009 inch (Ortho Organizers, San Marcos, CA) and regular clear elastomeric module (Ortho Organizers, San Marcos, CA).All tests were carried out in a dry state on an Instron universal testing machine (crosshead speed: 0.5 mm/min). The highest mean frictional resistance was found in ceramic brackets with nickel- titanium archwire ligated with elastomeric modules while minimum frictional resistance was found in metal slot ceramic brackets generated significantly lower frictional forces than ceramic brackets. Coated archwires shows highly significant reduction of the frictional resistance than their corresponding uncoated archwires. Ceramic brackets with metal slot and rhodium coated SS archwires seem to be a good alternative in space closure with sliding mechanics in patients with esthetic demands.

Keywords: *Resistance, Tooth, Ceramic Bracket, Metal Slot, In vitro.*

Introduction

Friction is defined *as the force (FR) that opposes a movement when an object moves tangentially against another. As two surfaces in contact slide against one another, several forces arise*. The frictional component (FR) is directed in a tangential direction to the surfaces in contact. Normal force component (N) is directed perpendicular to the contacting surfaces. Friction is directly proportional to the normal force and described by the equation FR = μN, where μ = the coefficient of friction.1 The nature of friction in orthodontics is multifactorial, derived from both a multitude of mechanical and biological factors.2 Many studies have been carried out to evaluate the factors that influence frictional resistance: Bracket and archwirematerials,3,4 surface structure of archwire,4 surface condition of the archwire and the bracket slot,5 bracket width, archwire sizeandshape,4,5 torque at thewire- bracket interface,6 type and amount of force exerted by ligation,7 use of self- ligating brackets,8 number of brackets 8 inter bracket distance, saliva, and influence of "oral functions, etc."9 In modern society, the esthetic aspect of orthodontic therapy is important due to the number of adults undergoing orthodontic therapy are increasing. Therefore, the development of appliance that combines both esthetic and adequate technical performance is an important goal. Ceramic brackets were developed to improve the esthetics during orthodontic treatment; however, in clinical use, they have high frictional resistance to sliding mechanics.5,10 Ceramic brackets with metal slot were recently developed to minimize the frictional characteristics of ceramics brackets.11 Coating on archwire material has been introduced to enhance esthetics and decrease friction. These wires are designed to be esthetically more acceptable by the patient. They are given a plastic tooth colored coating so that it can blend with the tooth color and also of ceramic brackets. Coating or refining the wire surface with other materials has an influence on frictional behavior. archwires with coating could possibly reduce frictional resistance at the bracket- archwire interface.12 Epoxy coated archwire is tooth colored and has superior wear resistance and color stability of 6-8 weeks.13Rhodium is a hard, silvery-white transition metal that is a member of the platinum group. These wires have low reflectivity which is promoted as conferring reduced visibility and .improved aesthetics.13 There were limited numbers of studies on frictional behavior of coated archwires and metal slot ceramic brackets. Therefore, the purpose of the present study was to evaluate and compare the frictional resistance generated by two types of brackets (ceramic, and metal slot ceramic) with eleven different archwires ligated by two different ligation materials (Stainless steel ligature and elastomeric modules).

Materials and methods

On the basis of bracket material, two types of brackets of roth prescription with 0.022 × 0.028 inch slot were used Ceramic brackets (3MUNITEKClarity ADVANCED, Monrovia, CA) and Ceramic brackets withmetal slot (3MUNITEK METAL REINFORCED, Monrovia, CA).Eleven different rectangular archwires of 0.016 × 0.022 inchwere used in the study as follows: Stainless steel and NiTi (Both archwires from Ortho Organizers, San Marcos, CA), three labial coated rectangular archwires:

Stainless steel (Noninium White, DENTAURUM, Ispringen, Germany), NiTi (Rematitan LITE,DENTAURUM, Ispringen, Germany) and thermoactiveNiTi (Tensic White, DENTAURUM, Ispringen, Germany), five full coated archwires: Stainless steel and NiTi (Tooth Tone Archwires, ORTHO TECHNOLOGY, Tampa, Florida, USA), Stainless steel and NiTi (Ultresthetic Tooth ColoredArchwire, G&H ORTHODONTICS, Greenwood, Indiana, USA) and NiTi (MemoriaNatura Preformed Archwires, LEONEAMERICA, Oxnard, CA) and Rhodium coated (Memoria Mimetic with Rhodium coating, LEONE S.p.a, Italy).The Ligation materials used were: Stainless steel ligature0.009 inch (Ortho Organizers, San Marcos, CA) and regularclear elastomeric module (Ortho Organizers,San Marcos, CA).Frictional resistance was measuredin grams with a universal testing machine (model 2519-107, Instron,Canton, MA, USA).

Testing Model Preparation

To simulate fixed appliance in the oral cavity a typodont model was taken as a testing model. Testing models were prepared the maxillary jaw of typodont model.(Figure 1a, 1b,)

Fig 1a: ceramic brackets bonded to typodont

Fig 1b: ceramic with metal slot brackets bonded to typodont

For canine retraction mechanics, testing models were prepared by removing 1st premolars from their position to simulate the condition of an extraction case. The canines were cut at the level of cervical line to facilitate its distal movement during sliding mechanics over the archwire. On the typodont model's teeth (central incisors, lateral incisors, canines, and 2nd premolars) brackets and buccal tubes (1st molars) were bonded at the clinically appropriate position using a chemical cure conventional bonding system. (Resilience, ORTHO TECHNOLOGY, Tampa, Florida, USA,).Similarly testing models were prepared for all the combinations Brackets and archwires were cleaned with acetone wipe to remove any surface impurities. The archwires to be tested were ligated to the brackets by stainless steel ligature and elastomeric module. For all the tests, ligation was done by the same individual. The stainless steel ligatures were initially fully tightened and then slightly slackened to allow the bracket to slide freely[14], the end of the ligature was then tucked in under the archwire. In case of elastomeric ligature, the elastomeric modules were placed immediately before each test to avoid ligature force decay[11].

Testing: The testing model was positioned vertically on the lower fixed member of the universal testing machine. For the movement of canine, a loop of stainless steel wire was made and loop was engaged in the hook of canine bracket. Free end of SS wire was held by upper cross head of testing machine (instron model 2519-107). The upper cross head member of the testing machine was adjusted to move upwards at a constant speed of 0.5 mm/min.5 Movement was started when canine was in contact with the distal surface of lateral incisor and stopped when canine just touched the mesial surface of 2st premolar. Total distance bracket travelled was 7 mm as recorded on computer. The tests were carried out in dry condition (to achieve the result in non-contaminated condition) and at room temperature5,11.

Statistical analysis

The collected data revised, tabulated and analyzed using SPSS V22.0 for Windows (SPSS Inc., Chicago, Illinois, USA). Quantitative variables were expressed as mean ± standard deviation (SD). Normal distribution of the quantitative variables was tested by Shapiro – Wilk test. Differences between independent groups were assessed by Student t-test for normally distributed quantitative. The effect of variables (bracket materials, ligation materials and eleven different archwires) on frictional resistance were observed and compared together by three-way analysis of variance and the significance of mean difference between the groups was done by Tukey's Post Hoc test. All results were considered statistically significant at the level of $p < 0.05$.

Results

The mean friction and standard deviation for each bracket- archwire- ligation combination is summarized in Table 1,2. The highest mean frictional resistance was found in ceramic brackets with NiTi archwire (223±3.14g) ligated with elastomeric modules

Table 1: Mean±SD, result of ANOVA and Tukey's test for comparison between frictional resistances induced by different types of brackets with SS ligature

Arch wires:↓	Brackets		*P* value
	Ceramic	Ceramic with metal slot	
	Mean±SD	Mean±SD	
SS	147.1±6.3	118.5±8.73	<0.001*
NiTi	155.2±7.9	130.6±6.5	<0.001*
Orth tech SS	125.8±5.5	113.6±3.9	<0.001*
Orth tech NiTi	135.6±5.6	128.2±3.9	<0.001*
Tensic	145.5±5.7	102.5±8.67	<0.001*
Remat	124.9±3.7	90.4±5.48	<0.001*
Non	100.2±7.3	85.8±6.37	<0.001*
Prefor	130.2±6.5	111.7±8.6	<0.001*
G&H SS	119 ±6.16	70.64±3.12	<0.001*
Rhodium	103.6±7.5	56.5±7.02	<0.001*
G&H NiTi	*122±3.6*	*116.6±5.6*	*<0.001**

**Significant at p ≤0.05*

Table 2: Mean±SD, result of ANOVA and Tukey's test for comparison between frictional resistances induced by different types of brackets with Elastomeric module ligature.

Arch wires:↓	Brackets		*P* value
	Ceramic	Ceramic with metal slot	
	Mean±SD	Mean±SD	
SS	202.9±4.6	162.45±5.56	<0.001*
NiTi	216±3.14	169±7.75	<0.001*
Orth tech SS	189.5±7.17	123.9±8.23	<0.001*
Orth tech NiTi	197.3±6.2	155.09±5.79	<0.001*
Tensic	158.2±5.64	123.9±7.28	<0.001*
Remat	146.2±5.46	127.73±6.63	<0.001*
Non	141.7±4.97	125.49±4.7	<0.001*
Prefor	154.2±7.6	121.6±9.76	<0.001*
G&H SS	122.9±6.83	86.29±5.49	<0.001*
Rhodium	145.68±3.6	64.63±8.91	<0.001*
G&H NiTi	132.2±6.6	125.7±6.46	<0.001*

**Significant at p ≤0.05*

Discussion

Orthodontic tooth movement is dependent on the ability of the clinician to use controlled mechanical forces to stimulate biologic responses within the periodontium.15The clinician should be aware of the characteristics of the orthodontic appliances, wires and ligature material that contribute to friction during sliding mechanics and the extent of the amount of force expected to be reduced by friction.3In the present study, the effect of bracket material, ligation material, and different archwires on frictional resistance was studied. Since frictional resistance at the bracket‐archwire interface is mostly affected by these variables. Majority of investigators used straight length archwire and fixed the bracket over models and draw the straight length archwire through the brackets in the Instron universal testing machine16.only few studies used typodont model.17,18 This does not fully simulate the clinical reality, because clinically moving teeth during sliding mechanics do not occur in a straight line. The method used in the present study was designed to closely reproduce the clinical situation.

A typodont model was used as testing model to simulate orthodontic appliance. The present study was carried out in dry conditions; to achieve results in no contaminated conditions, as observed in many previous studies.5,9,11The ceramic brackets showed the significantly higher frictional resistance (P<0.001) compared with ceramic brackets with metal slot. A possible explanation is that ceramics have a higher coefficient of friction than stainless steel because of increased surface roughness, hardness, stiffness and porosity of the material surface. Manufacturing process, finishing, and polishing are also difficult; this might explain the granular and pitted surface of the ceramic brackets.19The ceramic bracket with metal slot showed the lowest values of the frictional resistance, probably because its slot is reinforced with metal, which prevents direct contact between ceramic and archwire. The metal slot appears to cause the ceramic bracket to behave more like a stainless steel bracket than a conventional ceramic bracket in terms of static and kinetic frictional resistance as reported by Dickson and Jones.20The mode of ligation has significantly influenced the frictional values. Among all the bracket materials with different archwires when ligated with stainless steel ligature showed significantly less frictional resistance than elastomeric module, this finding was in correlation with certain previous studies. 21,22,23 Stainless steel ligature tying is subjective and can be variable, but in the present study all the ligations were done by the same individual and by the same pattern.24 in the present study, the bracket‐archwire

combinations were tested immediately after ligation with elastomeric modules so not much of force decay would have occurred.11Nickel‐ titanium archwires shows higher frictional resistance (P<0.001) then stainless steel archwires these findings were in accordance with the findings of previous studies21,.22,,24Stainless steel archwires have the smoother surface than nickel‐ titanium so they have less frictional resistance. NiTi archwires have greater surface roughness than compared with stainless steel archwires.19,21 NiTi archwires are more flexible than stainless steel archwires so they can bind during sliding mechanics and produce more resistance to movement.

In the present study, all coated archwires were tested had low friction than uncoated archwires with the two bracket types. This finding was consistent in the present study for both stainless steel and NiTi coated archwires. This result of the present study was also in agreement with the result of few previous studies.[25,26]

The practical relevance of this finding might be interesting, given that coated archwires has excellent aesthetic properties together with their improved frictional performance, may lead to widespread use of this type of archwires in orthodontic practice.

Conclusions

1. The highest frictional resistance was observed between Ceramic bracket and NiTiarchwire combination ligated by Elastomeric module
2. Ceramic brackets with metal slot and Rhodium coated archwire seem to be a good alternative to conventional stainless steel brackets and archwires in space closure with sliding mechanics in patients with esthetic demands.
3. All Coated archwires evaluated in this study reduce frictional resistance between brackets and archwires.

References

1. Rabinowicz E. Friction and Wear of Materials.1st ed. New York: Wiley; 1965.
2. Nanda R, Ghosh J. Biomechanical considerations in sliding mechanics. In: Nanda R, editor. Biomechanics in Clinical Orthodontics.Philadelphia, PA: WB Saunders; 1997. p. 188‐ 217.
3. Frank C, Nikolai R. A comparative study of frictional resistancesbetween or thodontic bracket and arch wire. Am J Or thod1980;78:593‐ 609.
4. Kapila S, Angolkar P, Duncanson M, Nanda R. Evaluation offriction between edgewise stainless steel brackets and orthodonticwires of four alloys. Am J OrthodDentofacialOrthop 1990;98:117‐ 26.
5. Kusy R, Whitley J. Coefficients of friction for arch wires in stainlesssteel and polycrystalline alumina bracket slots. I. The dry state. Am JOrthodDentofacialOrthop 1990;98:300‐ 12.
6. Ogata R, Nanda R, Duncanson M, Sinha P, Currier G.Frictional resistances in stainless steel bracket‐ wire combinations with effects of vertical deflections. Am J OrthodDentofacialOrthop1996;109:535‐ 42.
7. Hain M, Dhopatkar A, Rock P. The effect of ligation method onfriction in sliding mechanics. Am J OrthodDentofacialOrthop2003;123:416‐ 22.
8. Tecco S, Festa F, Caputi S, Traini T, Di Iorio D, D'Attilio M. Friction ofconventional and self‐ ligating brackets using a 10 bracket model.Angle Orthod 2005;75:1041‐ 5.
9. Braun S, Bluestein M, Moore B, Benson G. Friction in perspective.Am J OrthodDentofacialOrthop 1999;115:619‐ 27.
10. Loftus B, Artun J, Nicholls J, Alonzo T, Stoner J. Evaluation offriction during sliding tooth movement in various bracket‐ arch wirecombinations. Am J OrthodDentofacialOrthop 1999;116:336‐ 45.
11. Cacciafesta V, Sfondrini M, Scribante A, Klersy C, Auricchio F.Evaluation of friction of conventional and metal‐ insert ceramicbrackets in various bracket‐ archwire combinations. Am J OrthodDentofacialOrthop 2003;124:403‐ 9.
12. Farronato G, Maijer R, Carìa M, Esposito L, Alberzonid D, Cacciatore G.The effect of Teflon coating on the resistance to sliding of orthodonticarchwires. Eur J Orthod 2011;8:1‐ 8.
13. Malik N. et al. a review of orthodontic archwires, journal of orofacial research, January-march 2015;5(1):6-11.
14. Bednar J, Gruendeman G, Sandrik J. A comparative study of frictional forces between orthodontic brackets and arch wires. Am J OrthodDentofacialOrthop. 1991,100 (6): 513-22.
15. De Franco D, Spiller R, Jr. Frictional resistances using Teflon-coated ligatures with various bracket-archwire combinations. Angle Orthod. 1995, 65 (1): 63-74.
16. Rossouw P, Kamelchuk L, Kusy R. A fundamental review of variables associated with low velocity frictional dynamics. SeminOrthod. 2003;9:223–35.
17. Alfonso M, Espinar E, Llamas J, Ruperez E, Manero J, Barrera J. Friction coefficients and wear rates of different orthodontic archwires in artificial saliva. J Mater Sci Mater Med. 2013, 24 (5): 1327-32.
18. Rudge P, Sherriff M, Bister D. A comparison of roughness parameters and friction coefficients of aesthetic archwires, European Journal of Orthodontics, 2015, 37(1).
19. Angolkar P, Kapila S, Duncanson M, Jr., Nanda R. Evaluation of friction between ceramic brackets and orthodontic wires of four alloys. Am J OrthodDentofacialOrthop. 1990, 98 (6): 499-6.
20. Dickson J, Jones S. Frictional characteristics of a modified ceramic bracket. J ClinOrthod 1996;30:516‐ 8.
21. Nishio C, da Motta A, Elias C, Mucha J. In vitro evaluation of frictional forces between archwires and ceramic brackets. Am J OrthodDentofacialOrthop. 2004, 125 (1): 56-64.
22. Sukh R, Singh G, Tandon P, Singh G, Singh A. A comparative study of frictional resistance during simulated canine retraction on typodont model. J Orthod Sci. 2013, 2 (2): 61-6.

23. Griffiths H, Sherriff M, Ireland A. Resistance to sliding with 3 types of elastomeric modules. Am J OrthodDentofacialOrthop 2005;127:670‐5.
24. Doshi U, Bhad‐Patil W. Static frictional force and surface roughness of various bracket and wire combinations. Am J OrthodDentofacialOrthop 2011;139:74‐9.
25. Singh D. Esthetic Archwires in Orthodontics- A Review, Oral Hyg Health 2016, 4:1.
26. Mendes K, Rossouw P. Friction: validation of manufacturer's claim. SeminOrthod. 2003, 9: 236-50.