REVISTA DE ODONTOLOGIA DA UNESP

ORIGINAL ARTICLE

Rev Odontol UNESP. 2018 July-Aug.; 47(4): 244-248
Doi: https://doi.org/10.1590/1807-2577.05318

Evaluation of friction in metal, ceramic and self-ligating brackets submitted to sliding mechanics

Avaliação do atrito em braquetes metálicos, cerâmicos e autoligados submetidos à mecânica de deslizamento

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Resumo

Objetivo: Visando avaliar os melhores resultados para um tratamento ortodôntico de premissa, esta pesquisa teve como objetivo verificar a força de atrito entre fio e braquetes ortodônticos na mecânica de deslizamento. **Material e método:** Foram utilizados três diferentes tipos de braquetes, sendo metálico convencional, metálico autoligado e estético policristalino convencional (n=10), totalizando 30 braquetes e fio retangular de aço inoxidável .019 x .025 polegadas. Foi utilizada uma placa de acrílico. O fio foi fixado aos braquetes (metálico convencional e estético policristalino convencional) com ligadura elastomérica estética. A placa de acrílico juntamente com o fio .019 x .025 polegadas montado foi fixada ao mordente da base da máquina de ensaio universal Instron 4411, de maneira que ficou posicionada perpendicular em relação ao solo. O braquete foi tracionado à velocidade de 5 mm/minuto através do segmento do fio por uma distância de 5mm. Para cada tipo de braquete foi realizado dez testes havendo a troca do conjunto braquete e fio em cada repetição. Os dados foram analisados por Análise de Variância um fator (p<0,0001) e Teste de Tukey (p<0,05). **Resultado:** Braquetes metálicos convencionais e autoligáveis apresentaram atrito similar (p>0,05), enquanto braquetes cerâmicos apresentaram maior resistência ao atrito durante o teste de deslizamento (p<0,05). **Conclusão:** Conclui-se que o tipo de braquete influenciou no valor de atrito obtido, sendo que melhores resultados foram encontrados quando foram utilizados os braquetes metálicos e autoligados. O braquete cerâmico apresentou maior atrito.

Descritores: Atrito dentário; fios ortodôntico; braquetes ortodônticos.

Abstract

Objective: With the purpose of evaluating the best results for a proposed orthodontic treatment, the aim of this research was to verify the frictional force between archwires and orthodontic brackets in sliding mechanics. **Material and method**: Three different types of brackets were used: conventional metal, self-ligating metal and conventional polycrystalline esthetic type (n=10), totaling 30 brackets and .019 x .025 inches stainless steel rectangular wire. An acrylic plate was used. The wire was fixed to the brackets (conventional metal and conventional polycrystalline esthetic) with esthetic elastomeric ligation. The acrylic plate together with the 019 x 0.025 inches wire fitted to it was attached to the base plate of the Instron 4411 universal test machine so that it was positioned perpendicular to the ground. The bracket was drawn through the archwire segment at a speed of 5 mm / minute for a distance of 5 mm. For each type of bracket, ten tests were performed, with the bracket and archwire set being changed for each repetition. Data were analyzed by one-way Analysis of Variance (p <0.0001) and the Tukey Test (p <0.05). **Result:** Convencional metal and self-ligating brackets presented similar friction (p>0.05), while ceramic bracket presented higher frictional resistance during sliding test (p<0.05). **Conclusion:** It was concluded that the type of bracket influenced the frictional force value obtained, and better results were found when the metal and self-ligating brackets were used. The ceramic bracket presented a higher frictional force value.

Descriptors: Dental friction; orthodontic wires; orthodontic brackets.

INTRODUCTION

Orthodontics has undergone innumerable scientific advancements over the years, such as improvement in diagnosis, technical advances and development of new materials that have increase the efficiency of treatment and satisfaction of patients. Orthodontic movement involves two types of mechanics: mechanics with friction or sliding mechanics, and mechanics without friction, or sectioned arch mechanics[1].

Friction may be defined as a force that is mutually tangent to the common limit of two objects in contact with one another, and that resist imminent sliding of one object against the other[2]. For tooth movement to occur, forces adequately applied to the tooth must overcome the friction between the bracket and archwire. If this friction is not overcome, little or no movement of the tooth may occur, which would hinder the orthodontic treatment and lead to its failure[3].

Sliding mechanics is commonly used in cases of tooth extractions, problems of discrepancy between the dental arches, and when there is severe crowding in the dental arch. The main disadvantage of this mechanics is the frictional force generated between the bracket and archwire during orthodontic movement. Various factors may influence the frictional resistance, such as: the composition of the brackets, archwires and ties, condition of the surface of arches, bracket slots, wire cross-section, torque at the interface between the archwire and bracket, type of bracket, saliva, and influence of oral functions[4]. Therefore, attention must be paid to the choice of materials in each treatment plan.

With the advances in Orthodontics, self-ligating brackets have become increasing famous because they have advantages such as: reducing chair-time due to rapid placement and removal of archwires; non-use of elastics; reduction in friction with the purpose of improving sliding mechanics, and requiring less dental chairside assisting[5]. Moreover, the self-ligating appliance produces physiologically more harmonious tooth movement than the conventional appliance[6].

Over the years, a need has arisen to offer more discrete fixed appliances due to the increasing number of adult patients who seek orthodontic treatment[7]. In the 1980s, ceramic brackets were introduced into dentistry, bringing about favorable esthetic benefits and better acceptance of treatment[8]. However, a disadvantage of these esthetic brackets is the frictional coefficient that is higher than that of metal brackets, so that it is necessary to consider the changes in friction between the supports and orthodontic archwires, because a higher frictional force must be created for the sliding technique, which could change the time of concluding treatment[9].

Considering that sliding mechanics is widely used by orthodontists, it is of the utmost importance to evaluate and choose which material will offer the best results and a lower frictional force. This will make it possible to perform faster and more efficient tooth movement, helping with quality and adequate stability on conclusion of treatment, without overlooking the biological aspect. Therefore, the aim of the present research was to evaluate the frictional force of three types of brackets (conventional metal, conventional esthetic, and self-ligating types) and a steel archwire on sliding mechanics. The intention was to verify whether the friction between esthetic brackets and .019 x .025 inches stainless steel archwire would be higher that of conventional metal and self-ligating brackets; and whether the self-ligating brackets would present lower frictional force than the conventional metal and conventional esthetic polycrystalline brackets.

MATERIAL AND METHOD

For the test, three types of brackets for mandibular incisors were used, namely: stainless steel Kirium Roth Abzil brackets – lot 8910401846. Manufactured and Distributed by 3M do Brasil Ltda. São José do Rio Preto - São Paulo - Brazil; stainless steel Portia Roth Abzil self-ligating brackets – lot 1604000503, and esthetic esthetic polycrystalline Kirium Roth Abzil brackets – lot 1609600205.

All the brackets had a 0.022x 0.028 inches slot. The archwire used was steel 0.019x 0.025 (Orthometric Produtos Médicos e Odontológicos Ltda- Manufactured and Distributed by - Av. Pedro de Toledo, 1482 Marília- São Paulo- S.P, Brazil). The elastomeric ligatures used were of transparent color (Lot: 2382215. Morelli, Sorocaba/S.P, Brazil).

To prepare the test specimens, a rectangular acrylic plate measuring 4 x 14 cm and 0.5cm thick was made (Figure 1). On it, a groove 1.5 cm deep and 1.2 cm wide was made at 2 cm from one of the extremities. On this acrylic plate, a segment of fixed appliance was mounted, composed of four mandibular incisor brackets (stainless steel Kirium Roth Abzil brackets). After marking the position for bonding each of the four brackets on the acrylic plate, this site was abraded with a 120 grain abrasive paper (3M, Sumaré, SP, Brazil) to guarantee better retention of the brackets. These brackets were

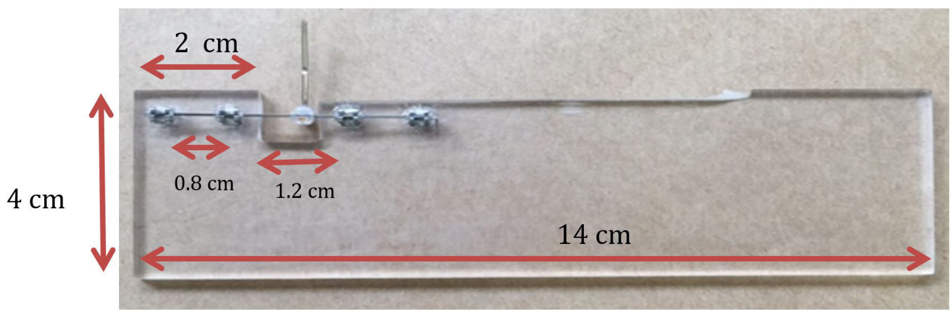

Figure 1. Acrylic plate with brackets positioned for the traction test.

bonded at a distance of 0.8cm between them and at a distance of 1.6cm from the region of the groove. The distance from the top edges of the brackets to the top extremity of the plate was 0.4 cm[10]. The brackets were fixed with cyanoacrylate (Super bonder, Loctite) and before the bond occurred, a .021 x .025 inches thick archwire (Orthometric) was fitted into the bracket channels, which allowed them to be aligned. After bonding, this archwire was removed[10].

The extremities of each archwire were bent with a 139 Pliers (Starlet, São Paulo, São Paulo, Brazil), so that they would be close to the terminal brackets on the acrylic plate, and could not slide inside the bracket channels. After this, the archwire was fixed to the brackets with an elastomeric ligature (Morelli) with the exception of the self-ligating bracket. Afterwards the mandibular incisor test bracket was inserted on this archwire, in the region of the groove in the plate (Figure 1).

Assay to Determine the Frictional Force

For the friction test, an Instron universal test machine 4411 was used (Figure 2). A 50 g weight, corresponding to the mass of a mandibular incisor was used, and was supported on the sliding bracket, thus making it a more faithful test. Traction was applied to the bracket at a speed of 5mm/minute along the wire segment for a distance of 5 mm[10]. For each type of bracket n=10 tests were performed. After each test the bracket/archwire set was changed. The plate remained perpendicular to the ground. The test was performed in a dry medium.

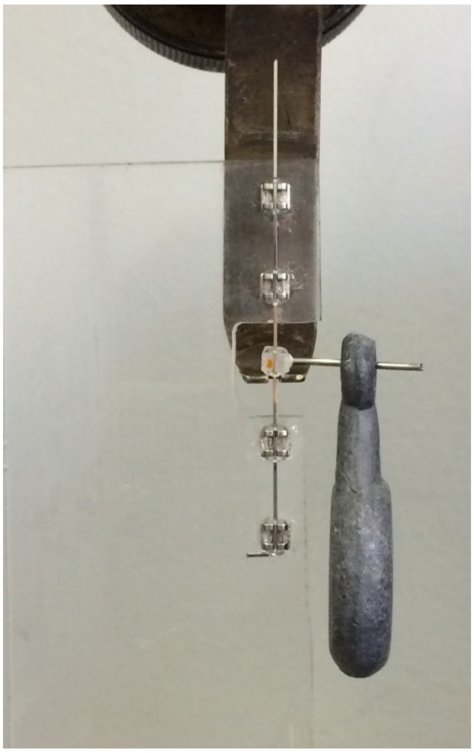

Figure 2. Friction test with conventional metal bracket.

Table 1. Mean frictional force (N) of brackets tested

Brackets	Mean Friction (N) Means	SD	
Ceramic	2.3	0.6	A
Metal	1.2	0.2	B
Self-ligating	1.3	0.2	B

Different letters indicate significant difference between the brackets ($p<0.05$).

The data were analyzed by the one-way Analysis of Variance and Tukey tests. For all the analyses, a level of significance of 5% was considered.

RESULT

One-way analysis of variance showed that there was statistically significant difference among the groups ($p<0.0001$). Thus, the Tukey test was performed with a level of significance of $p< 0.05$ and we observed that the conventional ceramic bracket presented significantly higher frictional force than the conventional metal and self-ligated brackets. The latter two types of brackets presented no significant differences between them relative to friction in sliding mechanics (Table 1).

DISCUSSION

In this research, the authors concluded that the type of bracket influenced the frictional force value obtained, since the ceramic bracket presented the highest frictional force value. In the tests, the best results were found when the metal and self-ligating brackets were used. The friction existent in orthodontic sliding mechanics presents the orthodontist with a clinical difficulty. Tooth movement occurs when the adequately applied forces overcome the friction between the bracket and archwire. If this friction is not overcome, little or no movement of the tooth may occur and may hinder the orthodontic treatment[11]. Factors such as the materials of which brackets, archwires and ties are made, condition of the surface of arches, bracket slots, wire cross-section, torque at the interface between the archwire and bracket, use of self-ligating brackets, and saliva may influence the frictional resistance[4].

With the demand for increasingly faster and more esthetic orthodontic treatments, but that still have satisfactory end results, new techniques and materials are launched on the market to help professionals.

In the present laboratory study, the authors compared the frictional resistance of three types of brackets of the same prescription, when associated with one type of steel archwire. Previous studies have been conducted by different authors to analyze the frictional force in sliding mechanics, and they were able to conclude that metal brackets presented lower frictional forces than ceramic brackets when they were compared in sliding mechanics[1,12].

In the present study, rectangular .019x .025 inches archwires were used due to the control of translation movement of the tooth. By using brackets with a 0.022x 0.028 inches slot, it is possible to fill and produce a small clearance with this wire, so that the tooth makes a proportional movement from both the apex of the root to the tip of the cuspid[13]. Another factor in the choice of archwire of this caliber is that in sliding mechanics this is the archwire of choice[14]. The choice of elastomeric ligatures in this study was made because this is the first choice of the majority of orthodontists[15].

Based on this study, the authors could affirm that the metal brackets had a frictional force that was equal to that of self-ligating brackets, in disagreement with some authors who also compared the frictional force between self-ligating and metal brackets, an found results indicating that the force calculated on metal brackets was significantly higher than that on self-ligating brackets[12,16,17]. On the other hand, the authors[18] compared the frictional force in sliding by using stainless steel self-ligating brackets and conventional stainless steel brackets with steel 0.019 x 0.025 inches archwires, and concluded that the self-ligating brackets presented higher frictional force values when compared with the conventional type.

In the present study, we observed that in sliding mechanics, the ceramic bracket presented significantly higher frictional force values than the metal and self-ligating brackets, corroborating the findings in the studies[19-21]. One of the causes of high frictional force on ceramic brackets may be due to the scratches found on these brackets, which make sliding difficult, thus increasing the time of orthodontic treatment[22].

In this research, the authors found that the self-ligating and conventional metal brackets produced similar frictional forces in the sliding technique, in disagreement with the others studies[22-24] who tested self-ligating and conventional metal brackets, and concluded that the frictional force values found were higher in the conventional brackets, one of the justifications for this result, according to the authors, would be that no elastic was used, thus making the wire run more easily through the self-ligating bracket, allowing a lower force and faster tooth sliding.

The fact that the best results in our research were found when the metal and self-ligating brackets were tested and compared, contradicts the initial hypothesis that the friction would be lower with the self-ligating brackets. The explanation for the fact that occurred would be the use of the weight that was supported on the test brackets. This weight caused an angulation in the bracket, which consequently caused an increase in the frictional force on sliding. Without this weight, we would possibly find other values, because as is known, the clearance between the self-ligating bracket and archwire is larger, consequently the angulation of the bracket that produces the friction would also be larger.

The clinical importance of this research to the orthodontic community is relevant, and further researches must be conducted to seek increasingly improved results in treatments.

CONCLUSION

By this study, the authors concluded that the type of bracket influenced the frictional force value found, and ceramic brackets presented higher frictional force values when compared with the other two types of metal and self-ligating brackets.

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CONFLICTS OF INTERESTS

The authors declare no conflicts of interest.

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Received: May 25, 2018
Accepted: August 3, 2018