

Evaluating the Effect of Air Abrasive Polishing on Friction and Surface Micromorphology of Ceramic Brackets Using Different Wires

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Abstract

Objectives: The aim of this in vitro study was to evaluate the Resistance to Sliding (RS) provided by ceramic (Perfect clear) sapphire ceramic brackets using round 2 types of orthodontic wires (Fiber-Reinforced Polymer Composite (FRPC) and Epoxy fully coated Stainless-Steel), before and after the use of sodium bicarbonate airborne particle abrasion, in an experimental model with 3 non levelled brackets and to evaluate the surface micromorphology of these brackets by means of scanning electron microscopy.

Materials and Methods: One commercial brands of ceramic brackets were evaluated. The fourty specimens were divided into two groups (n = 20) according to the two type of arch wires and each group was divided into four subgroup of five specimens according to the application or not of sodium bicarbonate airborne particle abrasion for (5, 10 and 20) seconds. A device adapted to a universal testing machine was used to simulate the movement of retraction in sliding mechanics, measuring the traction force needed to slide 10 mm of the wire over the test specimen brackets. The test speed was 5 mm/min. The data were analyzed by two-way analysis of variance (ANOVA) and Tukey test.

Conclusions: It may be concluded that it is not recommended to apply airborne particle abrasion on the slots of ceramic.

Key Words: *One commercial brands of ceramic brackets were evaluated.*

Introduction

With the advent of increasing adults' number opting for the orthodontic treatment, the development of the orthodontic appliances with ample emphasis on the aesthetics coupled with the optimum performance has become an exceedingly essential object or rather necessity of the day [1]. It has been partially resolved by the introduction of aesthetic brackets manufactured of ceramic or composite [2].

The ceramic brackets available nowadays are made of alumina either in poly-crystalline or mono-crystalline forms. The manufacturing process of mono-crystalline brackets results in a purer structure, a smoother surface, and a considerably harder substance than the fabrication of polycrystalline brackets [3].

Ceramic brackets currently represent an aesthetic alternative, although their use is limited. They abrade the enamel, and fracture more easily, and they have a higher coefficient of friction, increasing resistance to sliding [4].

However, most arch wires are still made of efficient, albeit un aesthetic, metal alloys such as stainless steel (SS) and nickel-titanium (NiTi) so that an aesthetic arch wire is highly desired to complement aesthetic brackets in clinical orthodontics [5].

Coating metallic arch wires by plastic resin materials was the main solution to offer aesthetic characteristics to the wires of metallic or silver colour appearance [6]. As the patients favor that shiny metal arch wires were not as apparent as opaque, an alternative could be wires with transparent or translucent features [7]. Moreover,

aesthetic coating of alloy arch wires are not durable clinically and tends to dehisce over a period of time [8]. Through composite technology, an aesthetic arch wire has been developed from continuous fibers and polymer matrix, giving rise to the fiber reinforced polymer composite (FRPC) arch wire [9]. The translucent nature of the polymer matrix confers the aesthetic property to this wire, while the fiber content gives the flexibility, overcoming the inherent problem of brittleness [10].

Friction is defined as a force that retards or resists movement related to two objects in contact. In sliding mechanics, friction is determined by the type of arch, type of bracket, and type of ligature.[11].

Although orthodontic treatment provides the functional and aesthetic correction of teeth, one of its inconvenient aspects is that the brackets (whether they are made of metal or ceramics) and other accessories allow a greater accumulation of residues and consequently, the formation of dental plaque, especially around the brackets. Professional prophylaxis must be performed to correct the patient's deficient tooth brushing, particularly with the use of sodium bicarbonate abrasion, a system that releases controlled jets of air, water, and sodium bicarbonate particles. It was introduced at the end of the 1970s as a fast and easy mechanism to remove dental plaque.[12]

Consequently, professional tooth cleaning could be extremely important for the maintenance of oral health, especially when patient compliance is inadequate or when dexterity is poor.[13] Compared to professional tooth cleaning with rubber cup and pumice, air-polishing devices are more effective for removing dental plaque, and in addition they promote less operator fatigue due to reduced working time.[14]

With regard to alterations to the dental substrate, it has been shown that the use of sodium bicarbonate airborne particle abrasion does not cause surface alterations in healthy enamel, but it does affect and change the micromorphology of dentin and cementum. [15] Therefore, the use of the sodium bicarbonate airborne particle abrasion is an efficient and safe method for removing dental plaque from healthy enamel, but its

use on exposed dentin and cementum must be avoided. [12,14-17].

Many studies evaluated the factors that could influence the frictional resistance, such as proprieties related to bracket and wires materials,[18-23] type and force of ligation,[20,24-26] and biological variables. [27,28] However, little research has been conducted to evaluate the effect of sodium bicarbonate air abrasive polishing on frictional resistance at tooth alignment and levelling phase of orthodontic treatment. Therefore, the aim of this study was to evaluate in vitro the frictional resistance (static friction) provided by Perfect Clear Sapphire brackets, using 2 types of aesthetic orthodontic wires size 0.018 inch (Fiber-Reinforced Polymer Composite (FRPC) arch wire and Epoxy fully coated Stainless-Steel arch wire) before and after the use of the sodium bicarbonate airborne particle abrasion, in an experimental model with 3 non levelled brackets and surface micromorphology of the brackets before and after applying sodium bicarbonate airborne particle abrasion, by means of scanning electron microscopy.

Materials and Methods

The study samples included 0.018 inches upper preformed round arch wires from two commercial brands .The first one was Fiber-Reinforced Polymer Composite (FRPC) arch wire manufactured by (Dentaurum, Germany.) and the second was Epoxy fully coated Stainless-Steel arch wire manufactured by IOS® (Tooth Tone® arches, Ortho Technology, USA).

The distal end of wires were cut into (5 cm.) length and investigated with one type commercial brand Sapphire Ceramic brackets {Perfect Clear® sapphire brackets from Hubit Co. (South Korea)}. Frictional resistance of 40 samples in this study was obtained from grouping the samples into 2 groups (n = 20) according to the type of arch wire and each group was divided into four subgroup of five specimens according to the time of air powder abrasive application.

In this present study, we used an experimental model with 3 non levelled brackets to assess the frictional forces generated during the dental alignment process. To

prepare the samples, 120 upper first premolar Sapphire ceramic edgewise brackets.022”(MBT prescription with a 0.022x0.028 inch slot with torque of (-7) and angulation of 0) were employed. Sapphire ceramic brackets were used because they are more aesthetic than stainless steel brackets and made from mono crystal alumina because the manufacturing process of mono-crystalline brackets result in pure and clear structure, smoother and harder surface than other type of ceramic brackets (Swartz, 1988).[29]

The samples were prepared by bonding 3 brackets on a preformed plastic block (37 mm length, 12 mm width, 10 mm height) made by Computerized Numerical Control (C.N.C), which was designed to simulate a non-aligned dental segment. The brackets were bonded with cyanoacrylate adhesive (Gucex star 502, china) and the bonding procedure was standardized by using the (C.N.C) plastic design and positioner showed in [Figure 1]. The end of the arch wire with a dimension of 0.018 inch cut into 5 cm and ligate with ligature elastic to brackets specimen.

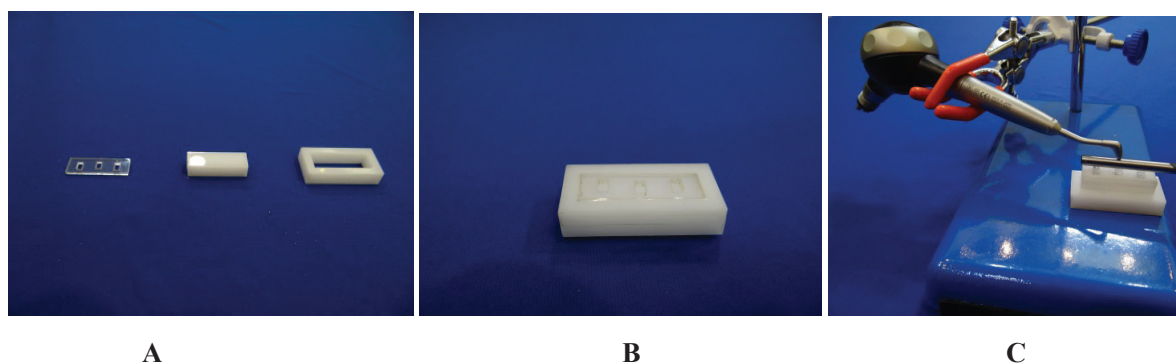
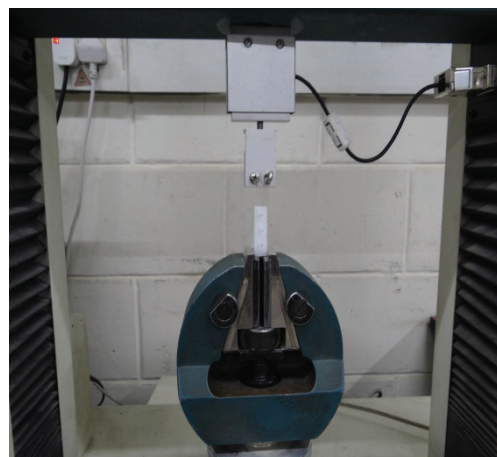


Figure.1: A-from the left to the right (C.N.C) plastic design, block and positioner. B-precisely bonding of a non-aligned brackets .C-standardized application of air abrasive powder.

The vertical discrepancy between the brackets was set at 1 mm to simulate a non-alignment situation in the segment of dental arch to be studied. The inter bracket distance was set at 11 mm, according to a previous study. [30]

The brackets and wires were washed in 95% ethanol and air-dried, and then one wire segment of 5 cm was positioned on the brackets slots for each sample. Several studies have documented that a high force generated by a tight ligation will cause an increase in the measurement of frictional force.[31] To reduce the potential for such bias, all ligations were done by the same operator using a needle holder in a standardized procedure. The ligatures used in this study were elastomeric modules (Super slick clear) IOS® (International Orthodontic Services, Stafford, USA)).

During the frictional force tests Static Friction (SF) and Kinetic Friction (KF) readings were performed. SF readings were obtained by determining the peak force (N) at the first 2 mm of wire displacement.



The test specimens were submitted to the tensile test in the mechanical testing machine computerized universal testing machine (Instron H50KT Tinius Olsen testing machine with 10 N load cell). Figure 2 shows the device and the bracket/wire positioned in the universal

testing machine. A maximum load of 5 kgf was used under dry conditions. Tensile force needed to slide 10 mm of the wire over the test specimen brackets for 2 minutes, at a speed of 5 mm per minute, was measured, and the maximum tensile force value obtained during the range of motion of each bracket was also measured. The data were obtained Newtons.

abrasion session for every bracket the remaining powder was discarded and a new (15 gm) of powder were poured into the tank of Prophy-Mate neo polishing system airflow hand piece (NSK Company, Japan) to prevent the level of powder from reaching below 50% of the tank in accordance with Parmagnani and Basting (2012). [32] The airborne abrasion was applied perpendicularly to the brackets at a distance of 5 mm for 10 seconds with a 2.3 bar pressure.

Surface micromorphology of the brackets was examined by scanning electron microscopy before and after application of sodium bicarbonate air abrasive polishing visualized at (50X, 500X, 1000X, 2000X) magnification is shown in figure 3 to figure 5.

Results

According to Table 1, it was observed that mean resistance was higher in the group that received airborne particle abrasion, regardless of the type of wire.

Epoxy fully coated Stainless-Steel arch wire showed a higher mean resistance than the Fiber-Reinforced Polymer Composite (FRPC) arch wire, both in the control group and after airborne particle abrasion.

Surface micro-morphologies of the brackets before and after jet application are shown in Figures 3 to 5. For the ceramic brackets, there was no surface alteration both at (50X, 500X, 1000X, 2000X) magnification.

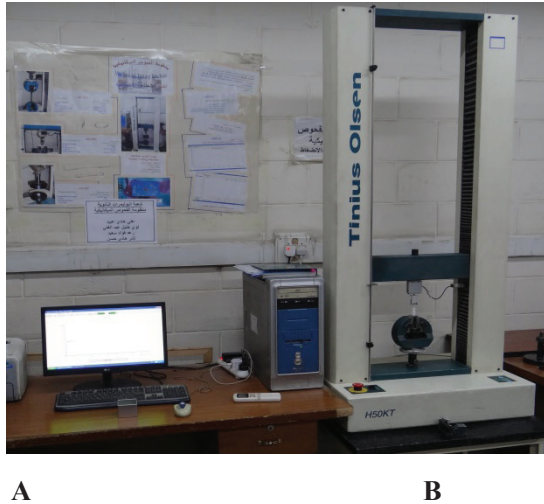


Figure 2: A// the device (Instron H50KT Tinius Olsen testing machine with 10 N load cell). B//the bracket/wire positioned in the universal testing machine

The sodium bicarbonate airborne abrasion was performed with a sodium bicarbonate appliance using AIR-N-GO Classic sodium bicarbonate polishing powder based in raspberry natural fresh flavour (Satelec A Company of Acteon Group, french). After each air

Table 1: Descriptive statistics of frictional resistance for two groups.

Groups	Duration	Mean	S.D	Min.	Max.
FRPC	Zero sec.	4.56	0.647	4	5.37
	5 sec.	4.914	0.903	4	5.95
	10 sec.	5.161	0.817	4.065	6.32
Epoxy SS	20 sec.	5.644	0.523	4.9	6.32
	Zero sec.	13.4	1.294	12	15.5
	5 sec.	15.1	1.084	13.5	16.5
	10 sec.	15,3	1.956	13.5	18
	20 sec.	15.8	2.540	13.5	18.5

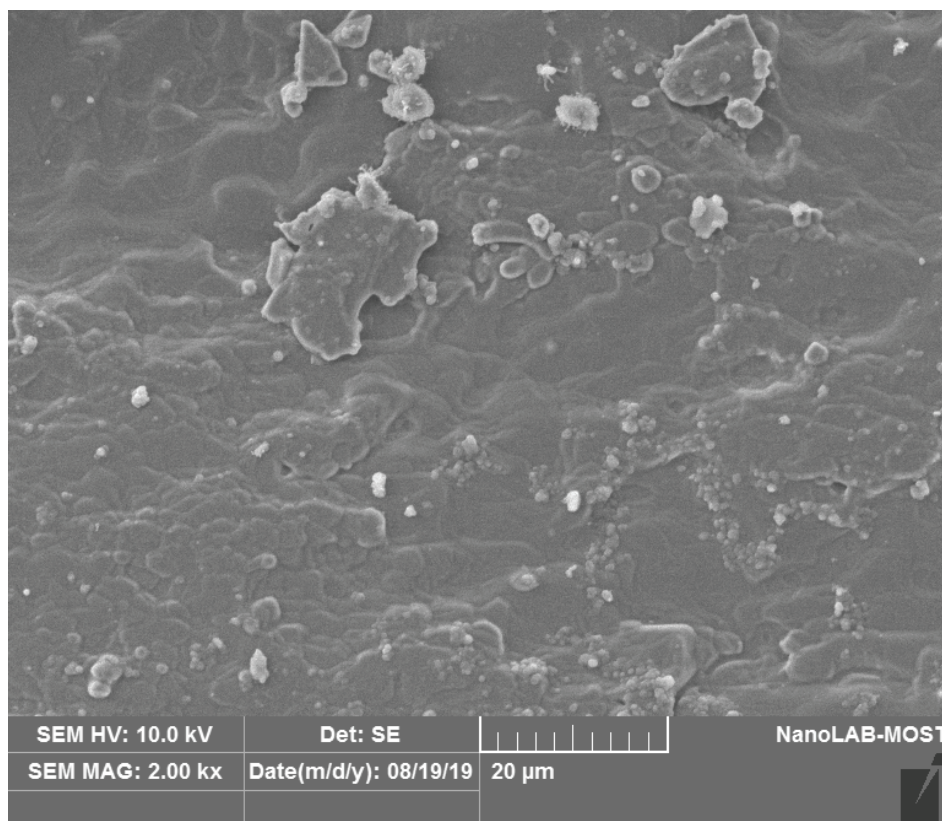


Figure 3: Micromorphology of slot of ceramic bracket before airborne particle abrasion at 2000X magnification and before insertion of any wires.

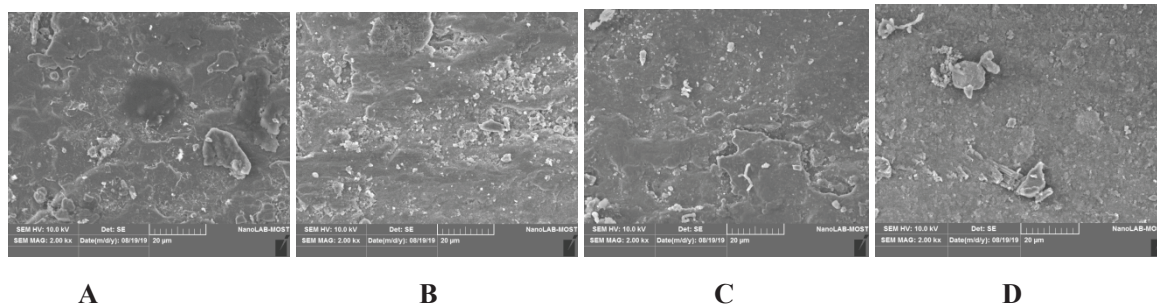


Figure 4: Micromorphology of slot of ceramic bracket after sliding 10 mm of the Fiber-Reinforced Polymer Composite (FRPC) arch wire at 2000X magnification. A// before airborne particle abrasion. B// after airborne particle abrasion for five seconds. C// after airborne particle abrasion for ten seconds. D// after airborne particle abrasion for twenty seconds.

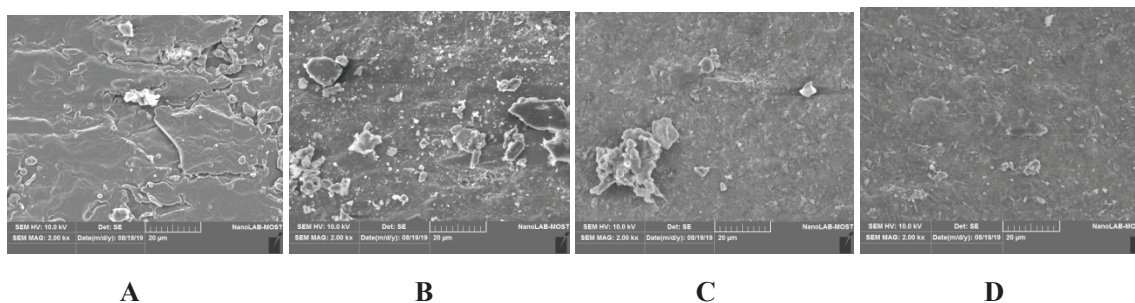


Figure 5: Micromorphology of slot of ceramic bracket after sliding 10 mm of the Epoxy fully coated Stainless-

Steel arch wire at 2000X magnification. A// before airborne particle abrasion. B// after airborne particle abrasion for five seconds. C// after airborne particle abrasion for ten seconds. D// after airborne particle abrasion for twenty seconds.

Discussion

the sliding of the brackets along the arch wire result in frictional forces that prevent the supporting tissue from attaining the optimal force level required for tooth movement [33]. Therefore to overcome the friction at the bracket-arch wire interface it is important to understand the orthodontic force so that a proper magnitude of force can be used to produce optimal biologic tooth movement, moreover orthodontic tooth movement is affected by a combination of biological and mechanical factors [34].

There are several ways to reduce friction by improvement of the material surface of the arch wire [35]. With ion implantation, the measured frictional losses ranged from 23.4 to 45.9 per cent [36]. The influence of the bracket material with regard to friction caused by the wire during sliding mechanics has been assessed, and it was found that ceramic brackets show higher friction than those made of stainless steel, not only due to the type of material, but particularly due to the irregularities on ceramic bracket surfaces.[31,38,39]

In the present study, mono-crystalline ceramic brackets were used. In general, the surface roughness of ceramic brackets is similar to that of a block of concrete in comparison with stainless steel brackets, which has a porous, irregular, and polyhedral surface, and this was observed in the scanning electron microscopy images in the present study, retaining a larger amount of sodium bicarbonate particles after the airborne particle abrasion and therefore, increasing friction. On the other hand, the sodium bicarbonate airborne particle abrasion did not cause surface alterations on ceramic brackets because the ceramic material hardness was greater than that of the metal material.

Therefore, it must be considered that jet application on the bracket slot should be avoided, and if it is done, abundant washing with water must be performed to

remove the residues, which occurs mainly in the ceramic brackets due to their greater surface irregularity.

Conclusions

Sodium bicarbonate air abrasive polishing is not recommended because the airborne abrasion of the brackets promoted a significant RS increase when the 2 types of wires (FRPC and the Epoxy fully coated Stainless-Steel) were used. Concerning to the Epoxy fully coated Stainless-Steel wire, the airborne abrasion effect on RS seems to be greater due to these material's properties.

Regardless of the type of wire tested, mean resistance was higher in the group that received sodium bicarbonate airborne particle abrasion.

The micromorphologic analysis showed that the airborne particle abrasion caused no changes on the surface of the ceramic brackets.

The application of airborne particle abrasion on the slots of ceramic brackets is not recommended.

Ethical Clearance: The Research Ethical Committee at scientific research by ethical approval of both MOH and MOHSER in Iraq

Conflict of Interest: None

Funding: Self-funding

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