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Evaluating The Effect Of Air Abrasive Polishing On Friction And Surface Micromorphology Of Ceramic Brackets Using Different Wires

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ABSTRACT

Objectives: To evaluate the frictional resistance of ceramic (Perfect clear) sapphire ceramic brackets using round stainless steel and rhodium coated stainless steel orthodontic wires before and after using sodium bicarbonate air abrasive polishing and to evaluate the surface micromorphology of these brackets by means of scanning electron microscopy.

Materials and Methods: 0ne 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.

Keywords: Airborne particle abrasion; Frictional resistance; Ceramic bracket

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INTRODUCTION

The growing aesthetic demand, especially by adults who began seeking orthodontic treatments, culminated in the first ceramic brackets being introduced in orthodontics at the end of 1986. This aesthetic alternative, an explicit attempt to eliminate the use of stainless steel brackets, has been developed with the use of new technologies in aesthetic bracket manufacturing.[1]

In many situations during orthodontic treatment (closure of extraction sites, space recovery, and at the initial phase of levelling and alignment of the teeth), the sliding between the orthodontic wire and brackets is an important mechanism that can affect the efficiency of tooth movement.

The Resistance to Sliding (SR) is divided into 3 components: the first component, classical friction (FR), is the force that resists the movement between two objects as the product of the normal load (N) and the coefficient of friction (m). FR exists as the only component of SR when the arch wire and bracket have clearance and are in a passive configuration and the angulation (q) between the arch wire and bracket is less than the critical angulation. When the wire contacts both ends of the bracket slot, an interference fit occurs, and binding (BI) arises as a second component of RS. The third component, notching (NO), occurs when the wire's plastic deformation happens at the wire-bracket corner interface. Tooth movement stops when a notched wire catches on the bracket corner and resumes only when the notch is released.[2] It has been suggested that notching is produced due to vertical movements of the teeth or wire during mastication.[3]

During orthodontic therapy, the fixed appliances increase the number of plaque retention sites and hence, the caries likelihood. 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.[4]

Air polishers have been available for use by dental professionals since the late 1970s. They are easy and efficient tools to remove extrinsic stains and plaque deposits from tooth surfaces.[5,6] It is well documented that air polishing is more effective at removing stain and plaque deposits than conventional scaling and rubber cup polishing. Air polishing requires less time for stain removal and is less tiring for the dental practioner.[7] It has been shown that using air polishers on enamel surfaces is safe and does not cause any loss of enamel following the procedure.[8,9] Air polishing may lead to gingival bleeding and abrasion. However, these effects are transient and have no clinical significance.[10,11]

The first powder to be used with air polishers was sodium bicarbonate ($NaHCO3$), which has a particle size of up to 250 µm.[12] lllll2

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.6 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.[13–17]

However, little research has been conducted to evaluate the effect of sodium bicarbonate air abrasive polishing on RS 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 orthodontic wires size 0.018 inch (Stainless-Steel and Rhodium-coated Stainless-Steel), 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

RS of 2 types of wires (Stainless- Steel and Rhodium-coated Stainless-Steel) in association with Sapphire Ceramic brackets {Perfect Clear® sapphire brackets from Hubit Co. (South Korea)} was investigated, and 40 samples were divided into 2 groups (n = 20) according to the type of arch wire and each group into four subgroup of five specimens according to the time of air powder abrasive application as described in Table 1. The wires were manufactured by IOS® (International Orthodontic Services, Stafford, USA).

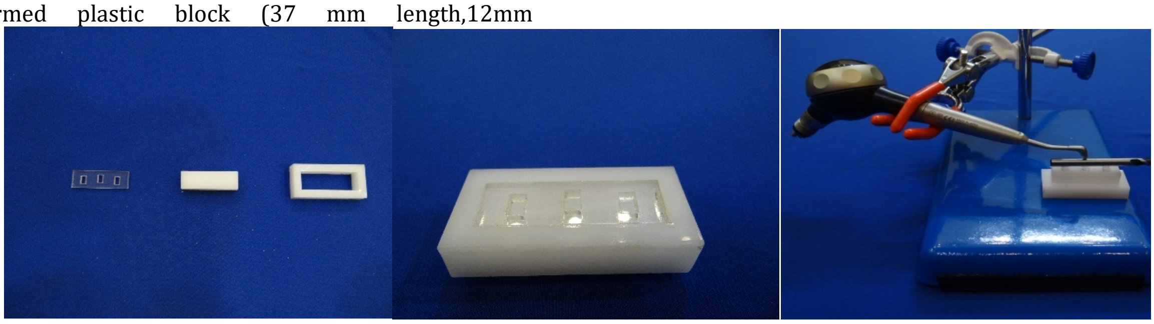
Table.1: Grouping of the test specimens

Arch wires size 0.018 inch	Without application of air abrasive powder	Five second of application	Ten second of application	Twenty second of application
Non coated stainless steel	No. of specimens (5)	No. of specimens (5)	No. of specimens (5)	No. of specimens (5)
Rhodium coated stainless steel	No. of specimens (5)	No. of specimens (5)	No. of specimens (5)	No. of specimens (5)

In this present study, we used an experimental model with 3 non leveled 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 monocrystalline brackets result in pure and clear structure, smoother and harder surface than other type of ceramic brackets (Swartz, 1988).[18]

The samples were prepared by bonding 3 brackets on a preformed plastic block (37 mm length,12mm width,10mm 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 an positioner showed in [Figure 1]. The end arch wire with a dimension of 0.018 inch cut into 5 cm and ligate with ligature elastic to brackets specimen.

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 11mm, according to a previous study.[19]



A B C

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 brackets and wires were washed in 95% ethanol and air-dried, and then one wire segment of 6 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.[20] 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.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 flavor (Satelec A Company of Acteon Group,french). After each air 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).[21] The airborne abrasion was applied perpendicularly to the brackets at a distance of 5 mm for 10 seconds with a 2.3 bar pressure.

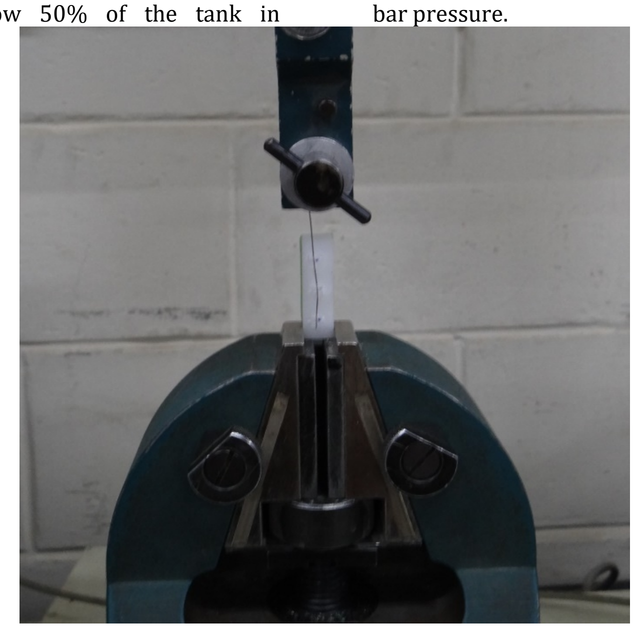


Figure 2: The device and the bracket/wire positioned in the universal testing machine.

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 11.

RESULTS

According to Table 2, it was observed that mean resistance was higher in the group that received airborne particle abrasion.

The stainless steel wire showed a higher mean resistance than the Rhodium coated stainless steel wire, both in the control group and after airborne particle abrasion.

Table 2: Descriptive statistics of frictional resistance for two groups.

Groups	Duration	Mean	S.D	Min.	Max.
SS	Zero sec.	20	2.850	16.5	23
	5 sec.	22.1	2.608	19.5	25.5
	10 sec.	24	3.652	20	26.7
	20 sec.	24.9	2.478	21.9	26.9
ROD	Zero sec.	18.3	1.789	16.5	20.5
	5 sec.	20	1.696	17.5	22
	10 sec.	22	1.541	20	24
	20 sec.	22.2	2.414	20	25

Surface micro-morphologies of the brackets before and after jet application are shown in Figures 3 to 11. For the ceramic brackets, there was no surface alteration both at (50X, 500X, 1000X, 2000X) magnification

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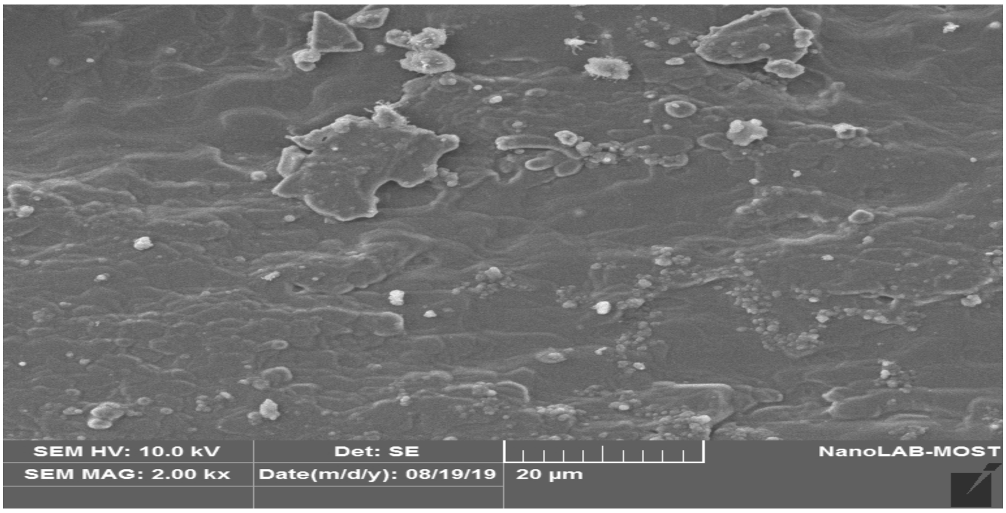

Figure 3: Micromorphology of slot of ceramic bracket before airborne particle abrasion at 2000X magnification and before insertion of any wires.

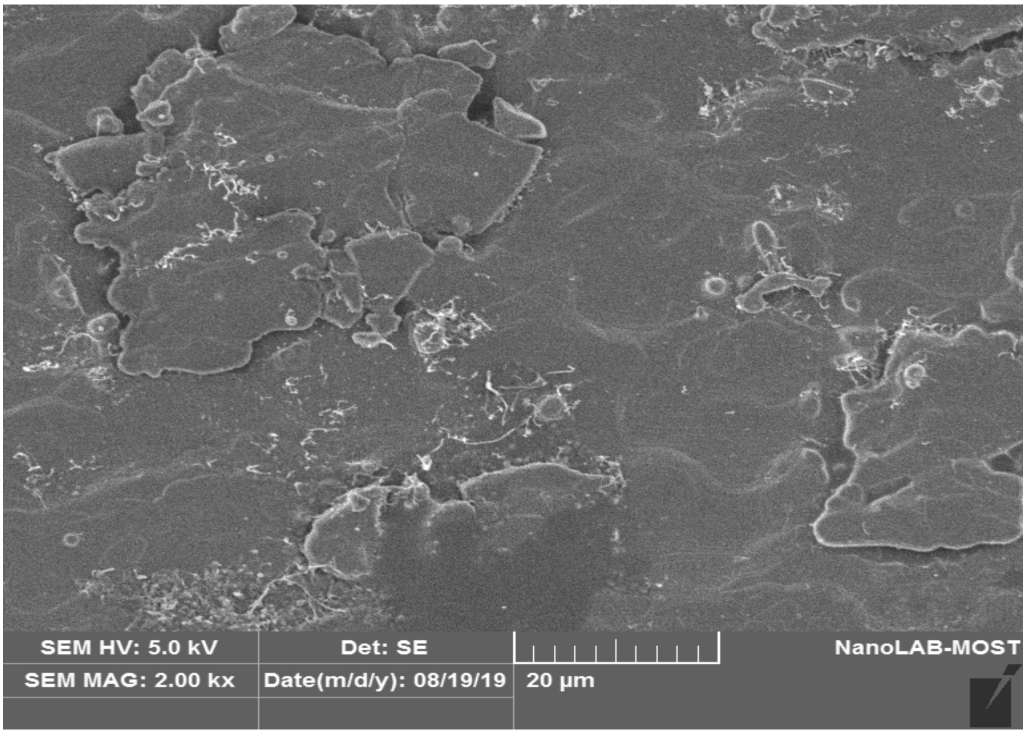

Figure 4: Micromorphology of slot of ceramic bracket before airborne particle abrasion at 2000X magnification and after sliding 10 mm of the stainless steel wire.

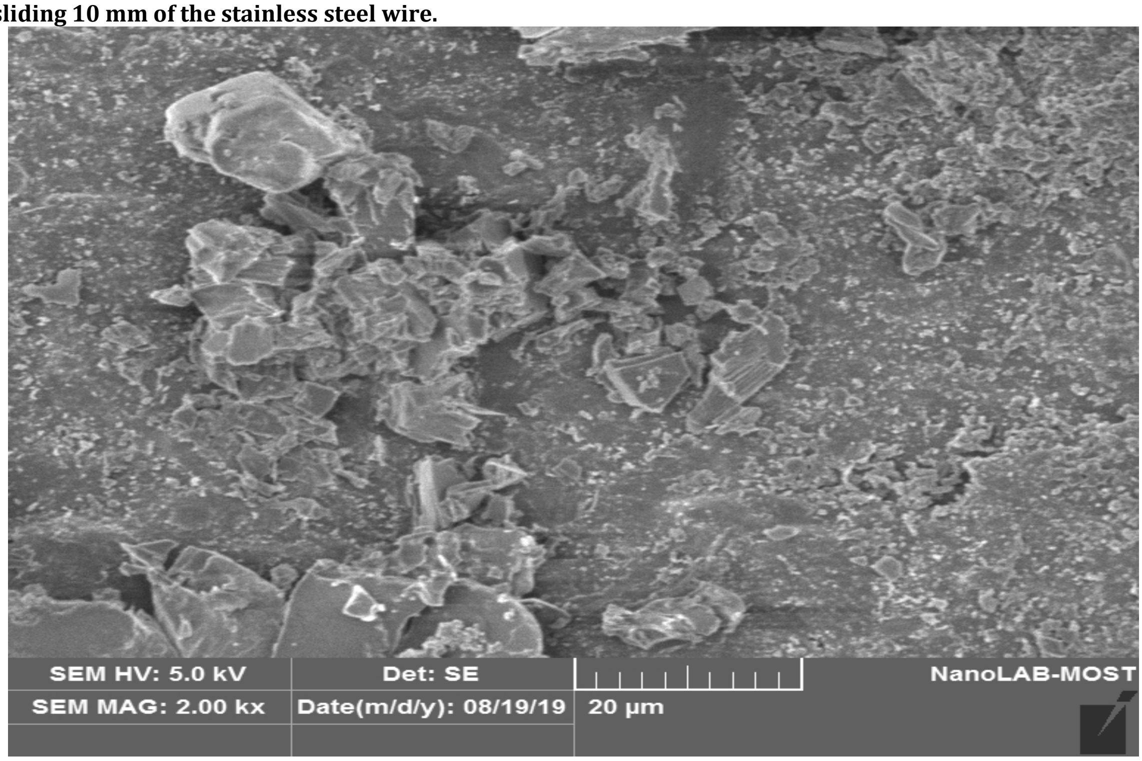

Figure 5: Micromorphology of slot of ceramic bracket after airborne particle abrasion for five seconds at 2000X magnification and after sliding 10 mm of the stainless steel wire.

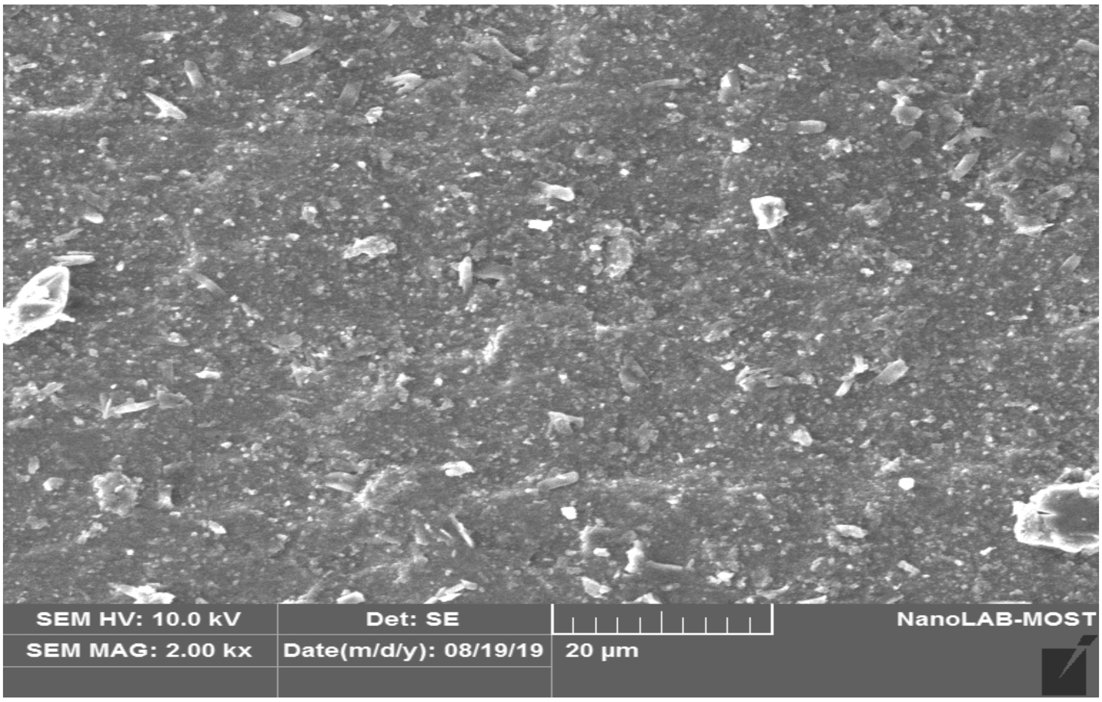

Figure 6: Micromorphology of slot of ceramic bracket after airborne particle abrasion for ten seconds at 2000X magnification and after sliding 10 mm of the stainless steel wire.

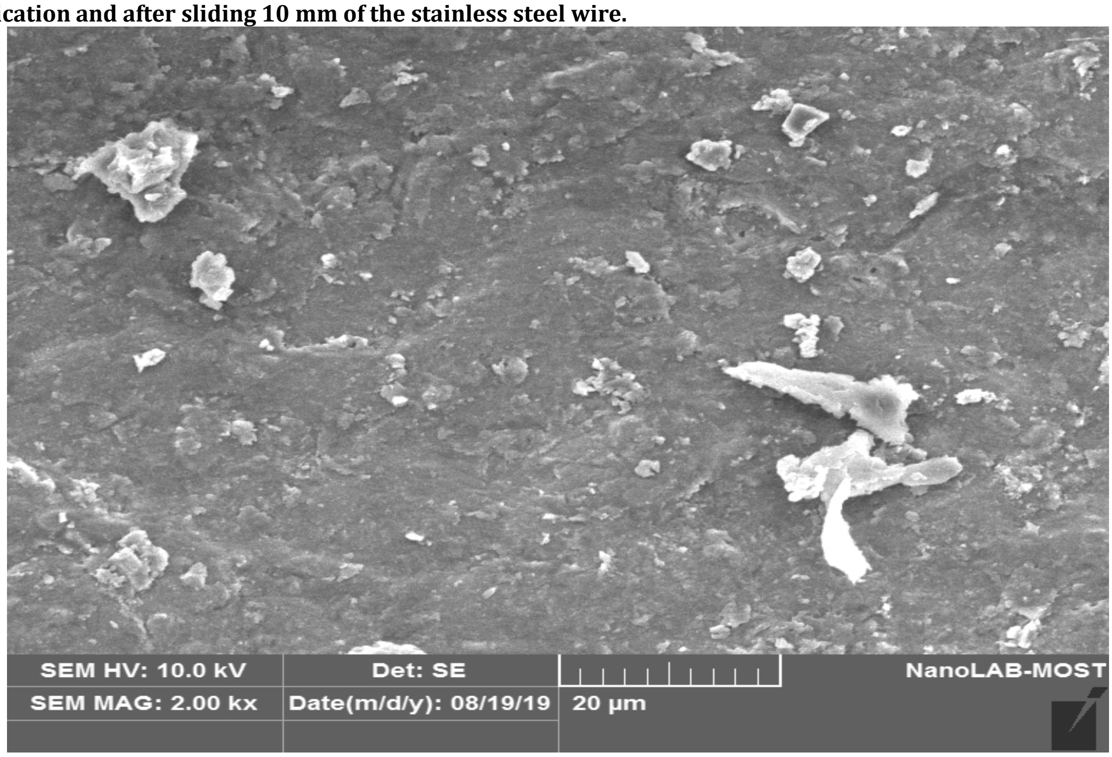

Figure 7: Micromorphology of slot of ceramic bracket after airborne particle abrasion for twenty seconds at 2000X magnification and after sliding 10 mm of the stainless steel wire.

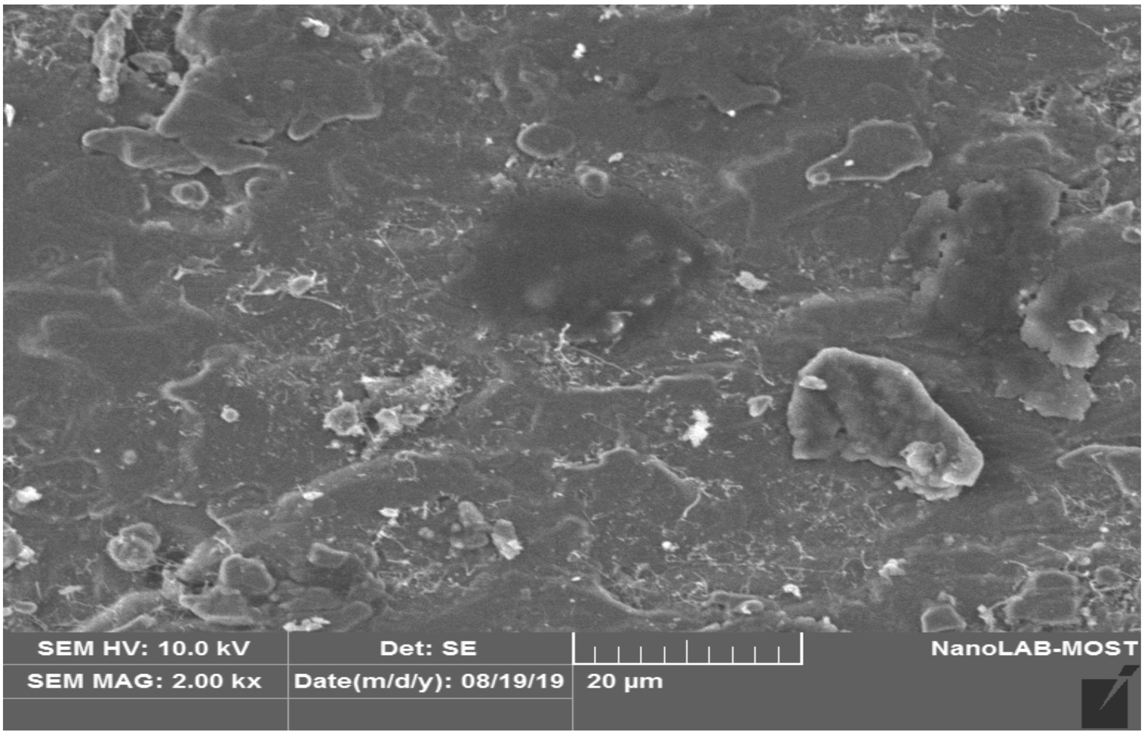

Figure 8: Micromorphology of slot of ceramic bracket before airborne particle abrasion at 2000X magnification and after sliding 10 mm of the rhodium coated stainless steel wire.

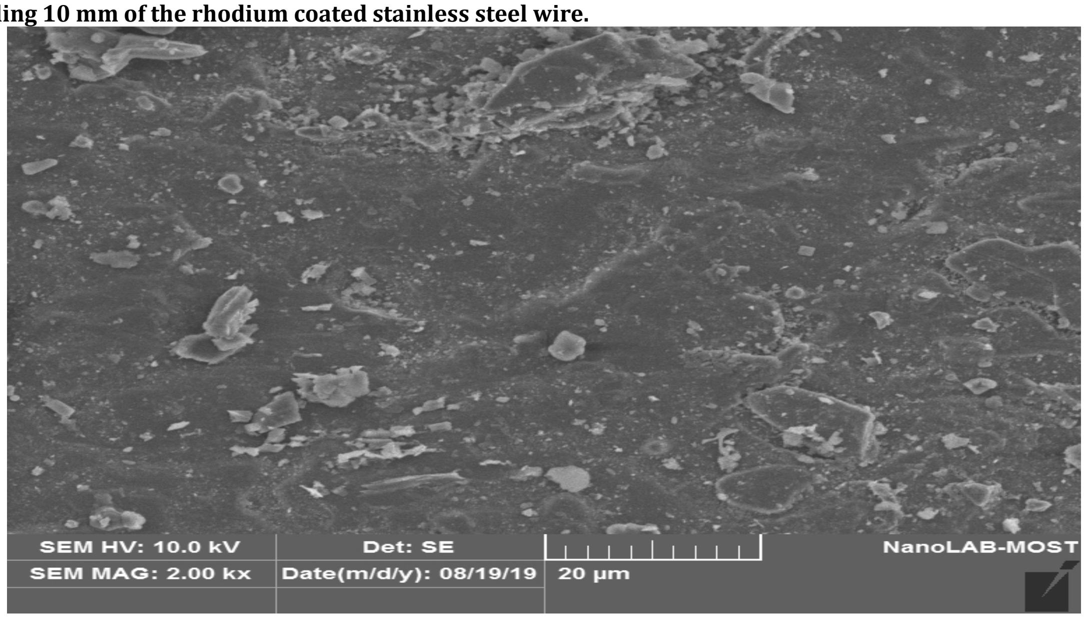

Figure 9: Micromorphology of slot of ceramic bracket after airborne particle abrasion for five seconds at 2000X magnification and after sliding 10 mm of the rhodium coated stainless steel wire.

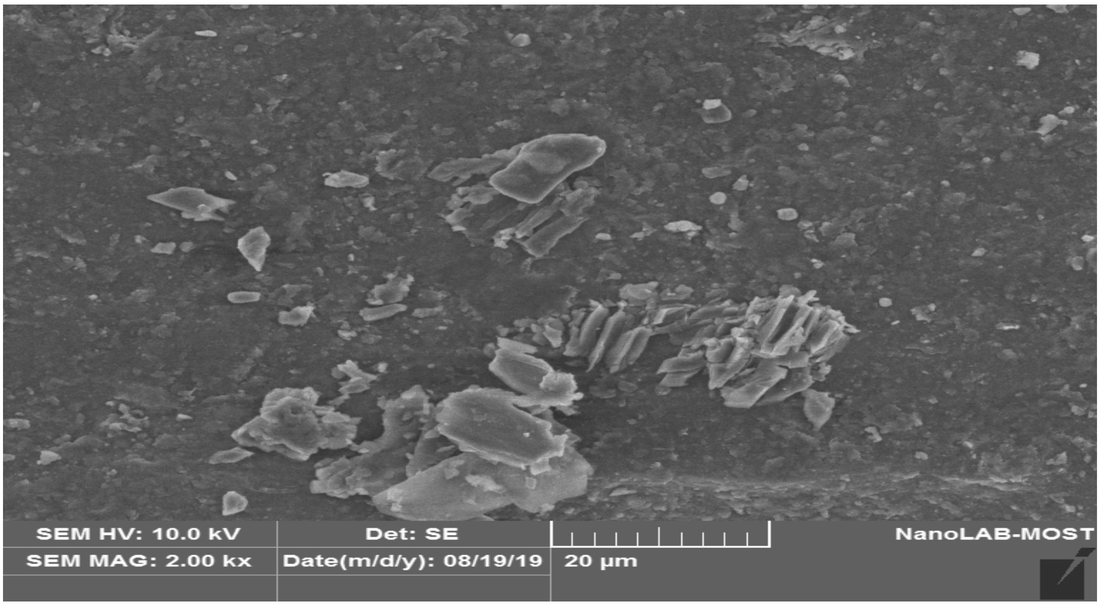

Figure 10: Micromorphology of slot of ceramic bracket after airborne particle abrasion for ten seconds at 2000X magnification and after sliding 10 mm of the rhodium coated stainless steel wire.

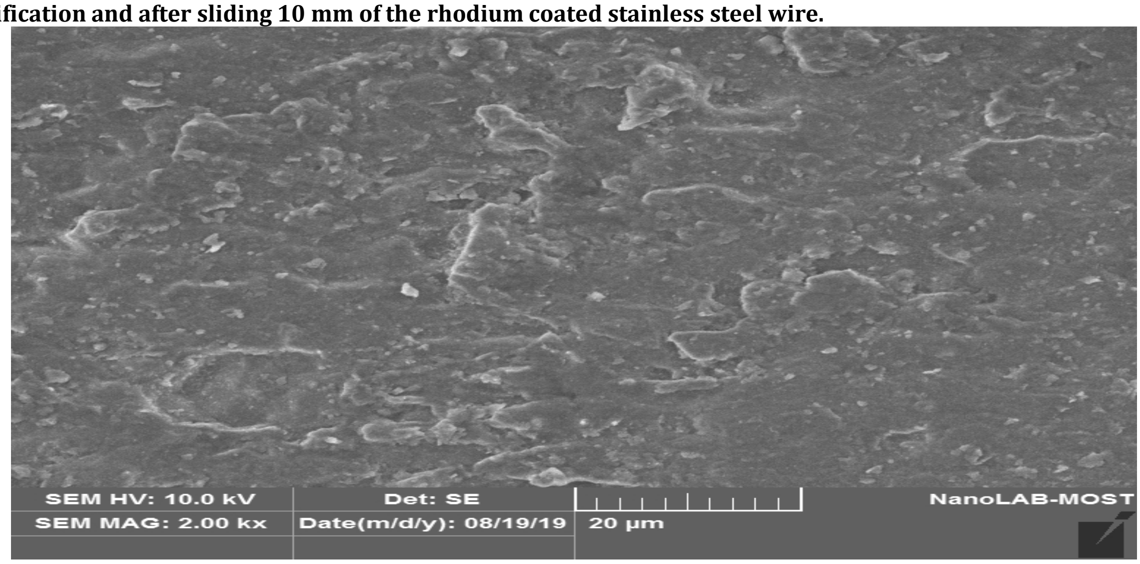

Figure 11: Micromorphology of slot of ceramic bracket after airborne particle abrasion for twenty seconds at 2000X magnification and after sliding 10 mm of the rhodium coated stainless steel wire.

DISCUSSION

Considering the aesthetic advantages of ceramic brackets in comparison with stainless steel accessories, their introduction made orthodontic treatments more attractive, especially to adult patients.[22]

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.[23–25]

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

- 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.

REFERENCES

1. Karamousos A, Athanasiou AE, Papadopoulos MA. Clinical characteristics and properties of ceramic brackets: a comprehensive review. Am J Orthod Dentofacial Orthop. 1997;112:34–40.
2. Kusy RP, Whitley JQ. Influence of archwire and bracket dimensions on sliding mechanics: Derivations and determinations of the critical contact angles for binding. Eur J Orthod 1999;21:199-208.
3. Articolo LC, Kusy K, Saunders CR, Kusy RP. Influence of ceramic and stainless steel brackets on the notching of archwires during clinical treatment. Eur J Orthod 2000;22:409-25.
4. Yeung SC, Howell S, Fahey P. Oral hygiene program for orthodontic patients. Am J Orthod Dentofacial Orthop 1989;96:208-13.
5. Gutmann ME. Air polishing: a comprehensive review of the literature. J Dent Hyg 1998 Summer;72(3):47-56.
6. Graumann SJ, Sensat ML, Stoltenberg JL. Air polishing: a review of current literature. J Dent Hyg 2013 Aug;87(4):173-180
7. Christensen R. Oral prophylaxis: Prophy-jet. Clin Res Assoc Newsl 1981;5:1-5.
8. Boyde A. Airpolishing effects on enamel, dentine, cement and bone. Br Dent J 1984 Apr 21;156(8):287-291.
9. Gerbo LR, Lacefield WR, Barnes CM, Russell CM. Enamel roughness after air-powder polishing. Am J Dent 1993 Apr;6(2): 96-98
10. Weaks LM, Lescher NB, Barnes CM, Holroyd SV. Clinical evaluation of the Prophy-Jet as an instrument for routine removal of tooth stain and plaque. J Periodontol 1984 Aug;55(8):486-488.
11. Kontturi-Narhi V, Markkanen S, Markkanen H. The gingival effects of dental airpolishing as evaluated by scanning electron microscopy. J Periodontol 1989 Jan;60(1):19-22.
12. Graumann SJ, Sensat ML, Stoltenberg JL. Air polishing: a review of current literature. J Dent Hyg 2013 Aug;87(4):173-180
13. Gerbo LR, Lacefield WR, Barnes CM, Russell CM. Enamel roughness after air powder polishing. Am J Dent. 1993;6: 96–98.
14. Hosaya Y, Johnston JW. Evaluation of various cleaning and polishing methods on primary enamel. J Pedod. 1989;13: 253–269.
15. Agger MS, Hovgaard O. Abrasiveness of an air-powder polishing system on root surfaces in vitro. Quintessence Int. 2001;2:407–411.
16. Boyde A. Airpolishing effects on enamel, dentine, cement and bone. Br Dent J. 1984;156:287–291.
17. Newman PS. The effects of an airbrasive instrument on dental hard tissues, skin and oral mucosa. Br Dent J. 1985; 159:9–12.
18. Swartz ML. Ceramic brackets. J Clin Orthod 1988; 22: 82–9.
19. Matarese G, Nucera R, Militi A, Mazza M, Portelli M, Festa F, et al. Evaluation of frictional forces during dental alignment: An experimental model with 3 nonleveled brackets. Am J Orthod Dentofacial Orthop 2008;133:708-15.
20. Tselepis M, Brockhurst P, West VC. The dynamic frictional resistance between orthodontic brackets and arch wires. Am J Orthod Dentofacial Orthop 1994;106:131-8.
21. Parmagnani EA, Basting RT. Effect of sodium bicarbonate air abrasive polishing on attrition and surface micromorphology of ceramic and stainless steel brackets. Angle Orthod 2012; 82: 351-62.
22. Burrow SJ. Friction and resistance to sliding in orthodontics: a critical review. Am J Orthod Dentofacial Orthop. 2009;135: 442–447
23. 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;98:499–506.
24. Keith O, Jones SP, Davies EH. The influence of bracket material, ligation force and wear on frictional resistance of orthodontic brackets. Br J Orthod. 1993;20: 109–115.
25. Tselepis M, Brockhurst P, West VC. The dynamic frictional resistance between orthodontic brackets and archwires. Am J Orthod Dentofacial Orthop. 1994;106:131–138.