ORIGINAL RESEARCH

Impact of Prophylactic Fluoride Agents On the Surface Roughness of Newer orthodontic arch wires

Dr.Suchareeta Panda[1], Dr. Anandu M[2], Dr.Goutham N [3], Dr.Pavithra Bai M[4], Dr.Saibalini Pani[5], Dr.Sakesth Rama Rao[6]

ABSTRACT

Fluorides serve an important part in orthodontic therapy as a prophylactic strategy. However, the harmful effects of fluoride are typically disregarded due to its widespread use as an anti-cariogenic agent in a variety of dental materials. The effects of these fluoride agents on conventional arch wires have been studied extensively but not on newer wires such as coated wires or braided wires. Hence this study was undertaken to assess the effects of prophylactic fluoride agents on the surface properties of non-coated Nickel-Titanium orthodontic wires and compare it with coated esthetic Ni-Ti wires and braided Ni-Ti wire.Materials and methods**:** In this study, we compared three packages of 270 orthodontic arch wires made of nickel titanium. For the control, the third set of 30 wires was stored in plastic vials containing 5ml of artificial saliva for two months. Subgroup a did not make use of any fluoride treatments. Samples from subgroup b were treated with Phos-flur gel for one minute every day for 2 months, while those from subgroup c were treated with Prevident 5000. An optic profilometer was used to measure the wires roughness. Results: The investigation found that both the acidulated fluoride agent (Phos-flur gel) and neutral fluoride agent (Prevident 5000) had an effect on the surface attributes of all three sets of wires. Coated esthetic Ni-Ti wires showed highest surface roughness followed by braided Ni-Ti wire. Conclusion: The findings of the research showed that using fluoride preventive treatments (such as mouthwash or gels) during orthodontic treatment decreases the arch wires characteristics.

Keywords

Surface topography, Surface roughness, Fluorides, Ni-Ti wires, Braided Ni-Ti wires, Coated Ni-Ti wires, Phosflur gel, Prevident 5000

Introduction

Maintaining a high standard of oral hygiene before to, during and after orthodontic treatment is crucial. Fluorides are used during orthodontic treatment primarily as a preventive measure[1]. However, although fluoride is widely used in dental products as an anti-cariogenic agent, its harmful consequences are generally disregarded[2]. The effects of these fluoride agents on conventional archwires have been studied extensively[3] but not on newer wires such as coated wires or braided wires.

1. Associate Professor, Department of Orthodontics, Institute Of Dental Sciences, Siksha 'O' Anusandhan University (Deemed to be University), Bhubaneswar, Odisha
2. Associate Professor, Department of Dentistry, PES University Of Medical Sciences (Deemed to be University), Banglore, Karnataka
3. Associate Professor, Department Of Orthodontics, V S Dental College And Hospital, Rajiv Gandhi University Of Health Sciences, Banglore, Karnataka
4. Professor, Department Of Orthodontics, Hi-Tech Dental College & Hospital, Utkal University, Bhubaneswar, Odisha
5. Assistant Professor, Department of Orthodontics, Institute Of Dental Sciences, Siksha 'O' Anusandhan University (Deemed to be University), Bhubaneswar, Odisha
6. Professor, Former HOD, Department Of Conservative Dentistry, Hi-Tech Dental College & Hospital, Bhubaneswar, Odisha

Correspondence:

Dr. Anandu M, Associate Professor, Department of Dentistry, PES University Of Medical (Deemed to be University), Banglore, Karnataka, Email: dranandu01@gmail.com Cell Phone:+918884322498

DOI: https://doi.org/10.3329/bjms.v23i10.71752

Aims and objectives:

The purpose of this research was to evaluate the surface properties of uncoated Nickel-Titanium orthodontic wires to those of coated esthetic Ni-Ti wires and braided Ni-Ti wires, as well as to assess the efficiency of fluoride-based prophylactic medications

Materials and Methods

For this research, three different 0.017 x 0.025 inch prefabricated arch wires made of nickel titanium were used. The straightened part of prefabricated wire 25mm was cut. A total of 270 samples were taken, 90 from each wire type. There were three sets of wires, each with 90 samples. Archwires were available in three different sizes: 0.017"X0.025" Nickel Titanium (set I), 0.017"X0.025" Coated Ni-Ti (set II) and 0.017"X0.025" Braided Ni- Ti (set III).

In this experiment, we employed the following fluoride agents:

Phos-flur gel (1.1% sodium fluoride acidulated phosphate, APF, 0.5% w/v fluoride, pH = 5.1; Colgate Oral Pharmaceuticals).

Prevident 5000 (1.1% sodium fluoride neutral agent, 0.5% w/v fluoride, pH = 7; Colgate Oral Pharmaceuticals).

The control group solution was artificial saliva (custom made). The formula is Water, NaCl 0.04%, KCl 0.04%, $CaCl_2$ 0.795%, NaH_2PO_4 0.078%, Na_2S 0.0005%, Urea 0.1%. H_3PO_4 was used to bring the pH of the test solution to 6.7.

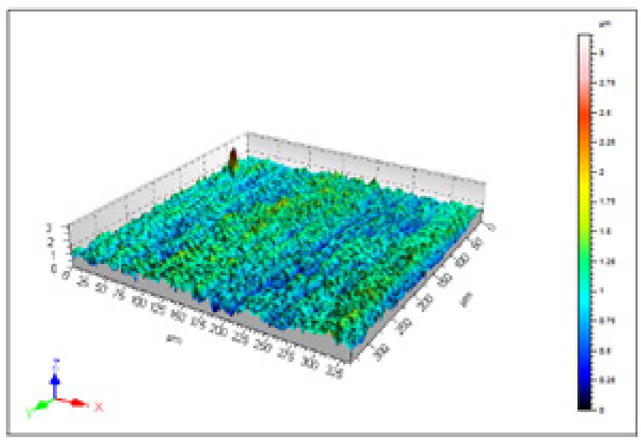
Each group of archwires was divided into 3 sub-groups: sub-group a (Control-Artificial saliva), sub-group b (Experimental-Phosflur gel), sub-group c (Experimental-Prevident 5000). Two months (control) were spent with all three sets of wires (group of 30) submerged in 5ml of artificial saliva in plastic vials. Subgroup a did not make use of any fluoride treatments. Phos-flur gel and Prevident 5000 were applied to samples from sub-group b and c for one minute every day for two months.

Methodology

All samples from the three groups were analyzed two months after being immersed and treated with fluoride chemicals. Two specimens were chosen at random from each set of experimental wires and analyzed with an optic profilometer. Each kind of wire underwent a One-way analysis of variance (ANOVA) with a 5% significance level (0.5) to assess whether or not there were statistically significant differences between the treatment groups. Pairwise comparisons between the control and experimental groups were performed using the Turkey post hoc test.

RESULTS

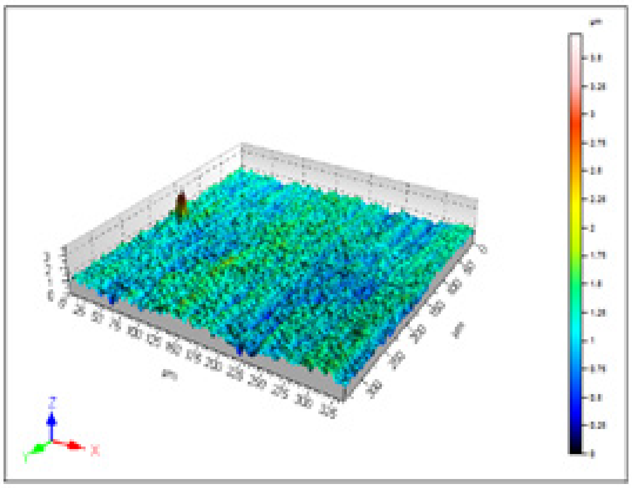
Figures 1 and 2 demonstrate the effects of an acidulated fluoride agent (Phos-flur gel) and a neutral fluoride agent (Prevident 5000) on the surface properties of the three sets of wires, respectively. Surface properties were reduced more by the acidulated fluoride agent (Phos-flur gel) than by the other fluoride agent. Images were taken using a computerized profilometer, Ra (the average height of roughness), Rq (the root mean square height of roughness), Rt (the maximumheight of roughness), and Rp (the peak height of roughness) were all computed.As compared to the sub-group a (control) in all three group of wires, sub-group b (Phos-flur- Figure.3,4,9,10,15,16) showed highest surface roughness followed by sub-group c (Prevident- Figure.5,6,11,12,17,18).When



Amplitude parameters - Roughness profile	Mean µm
Ra	0.115011
Rp	0.304302
Rq	0.143476
Rt	0.777027

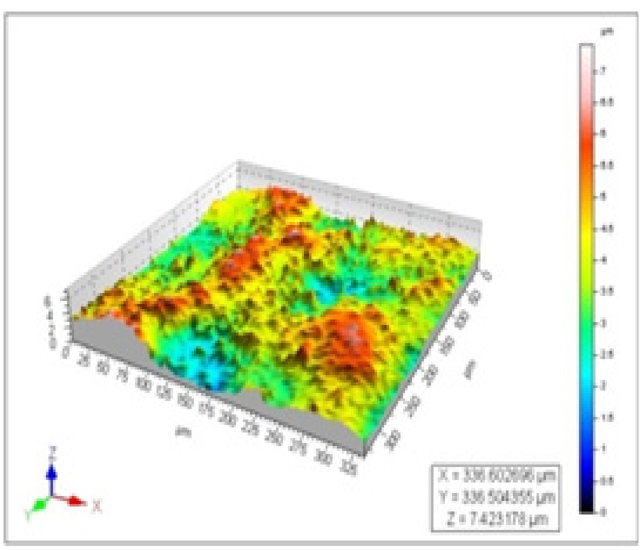
Fig 1: Optic Profilometer Analysis for Group I a Sample 1

compared between the three groups of wires, Group II (coated Ni-Ti- Figure.7-12) wires showed highest surface roughness followed by Group III (braidedNi-Ti, Figure.13-18) wires and Group I (non-coated Ni-Ti, Figure.1-6) wires. This study's findings confirmed that fluoride prophylactic agents had adiscernible impact on the surface properties of all three classes of Ni-Ti wires.



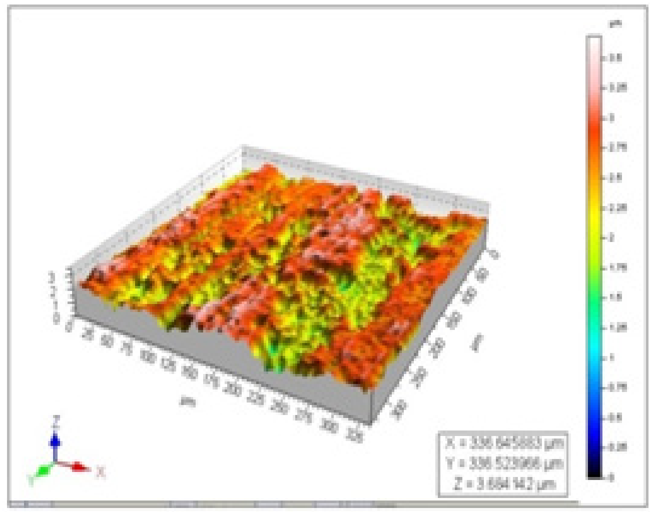
Amplitude parameters - Roughness profile	Mean µm
Ra	0.116170
Rp	0.295980
Rq	0.144736
Rt	0.764829

Fig 2: Optic Profilometer Analysis for Group I a Sample 2



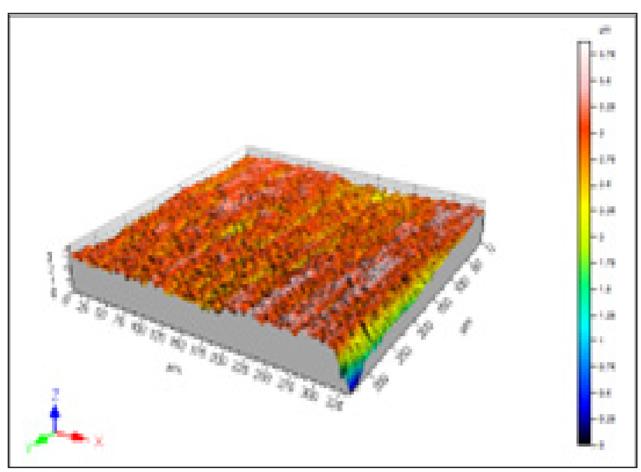
Amplitude parameters – Roughness profile	Mean µm
Ra	0.339760
Rp	1.015536
Rq	0.428717
Rt	2.468064

Fig 3: Optic Profilometer Analysis for Group I b Sample 1



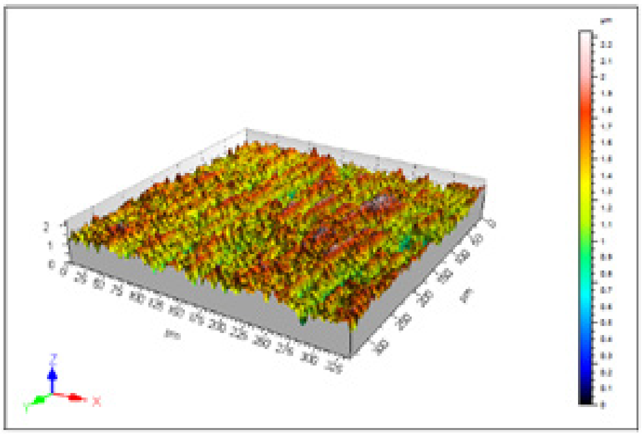
Amplitude parameters – Roughness profile	Mean µm
Ra	0.263930
Rp	0.597440
Rq	0.332244
Rt	1.964462

Fig 4: Optic Profilometer Analysis for Group I b Sample 2



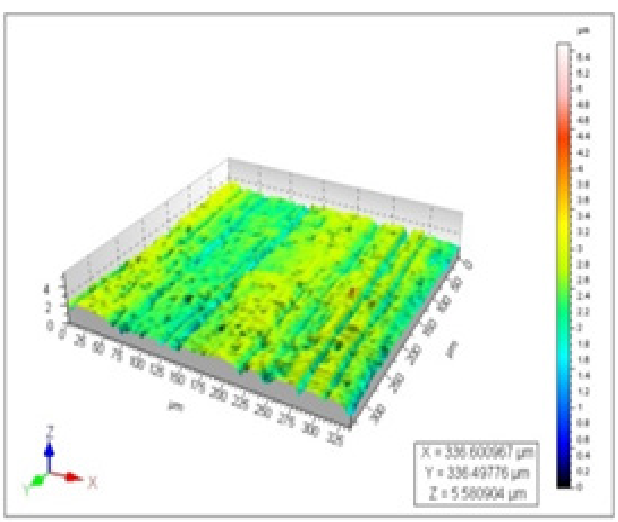
Amplitude parameters - Roughness profile	Mean µm
Ra	0.188360
Rp	0.312410
Rq	0.159331
Rt	0.845692

Fig 5: Optic Profilometer Analysis for Group I c Sample 1



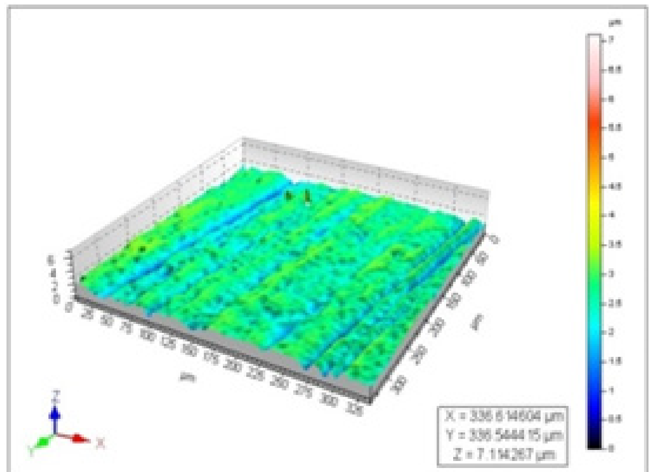
Amplitude parameters - Roughness profile	Mean µm
Ra	0.162784
Rp	0.386850
Rq	0.206805
Rt	1.118315

Fig 6: Optic Profilometer Analysis for Group I c Sample 2



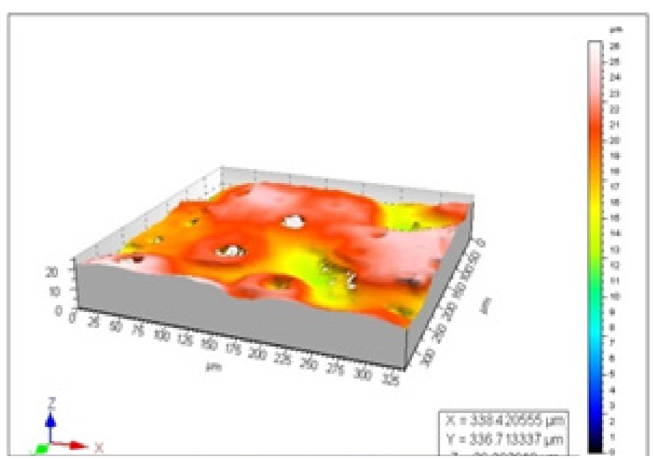
Amplitude parameters - Roughness profile	Mean µm
Ra	0.201958
Rp	0.478527
Rq	0.270178
Rt	1.807533

Fig 7: Optic Profilometer Analysis for Group II a Sample 1



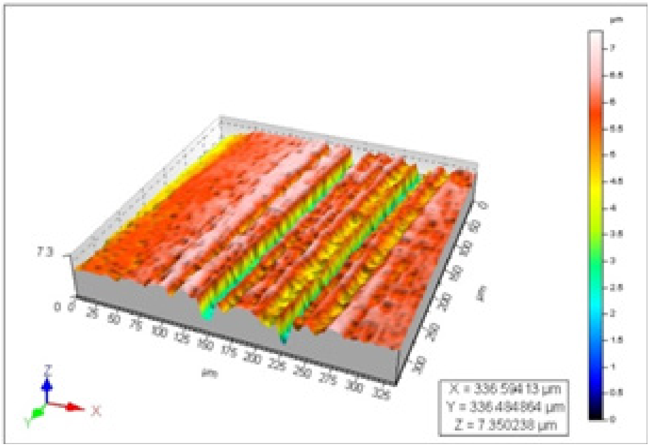
Amplitude parameters - Roughness profile	Mean µm
Ra	0.283264
Rp	0.612933
Rq	0.352155
Rt	2.020703

Fig 8: Optic Profilometer Analysis for Group II a Sample 2



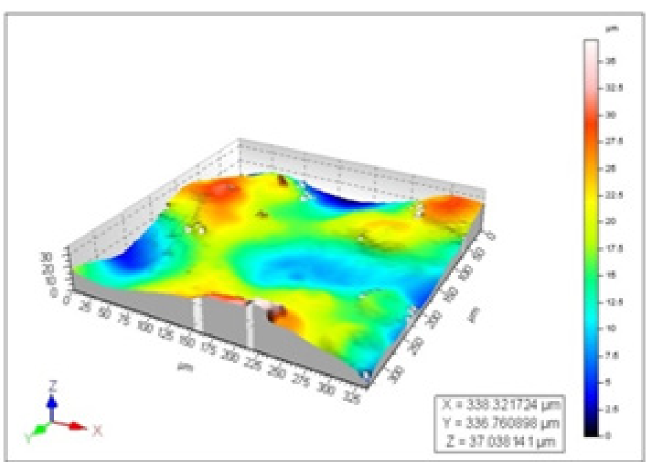
Amplitude parameters - Roughness profile	Mean µm
Ra	0.503633
Rp	1.224905
Rq	0.667223
Rt	3.643070

Fig 9: Optic Profilometer Analysis for Group II b Sample 1



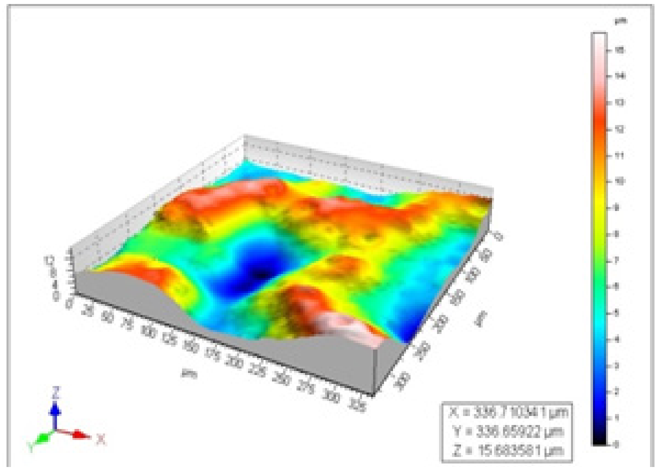
Amplitude parameters - Roughness profile	Mean µm
Ra	0.602223
Rp	1.169449
Rq	0.774575
Rt	4.393642

Fig 10: Optic Profilometer Analysis for Group II b Sample 2



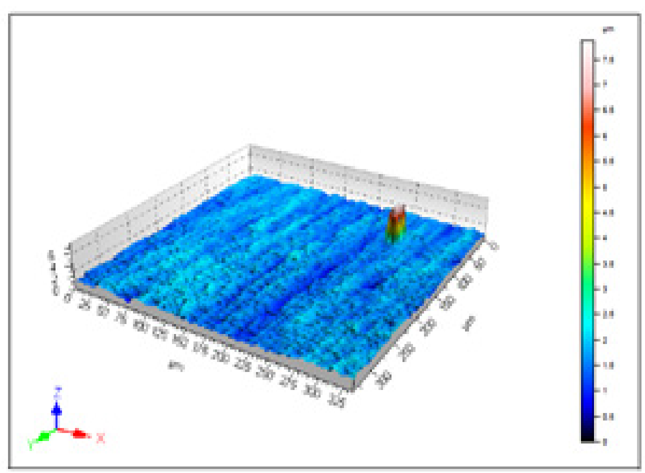
Amplitude parameters - Roughness profile	Mean µm
Ra	0.420621
Rp	0.940168
Rq	0.549221
Rt	3.254788

Fig 11: Optic Profilometer Analysis for Group II c Sample 1



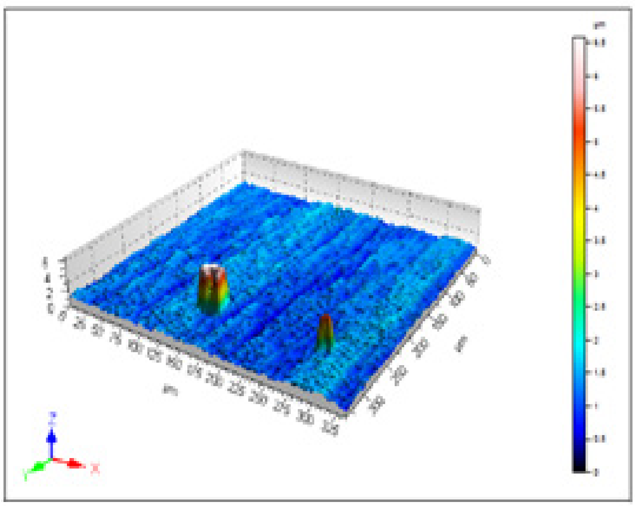
Amplitude parameters - Roughness profile	Mean µm
Ra	0.362822
Rp	0.763980
Rq	0.432579
Rt	2.053138

Fig 12: Optic Profilometer Analysis for Group II c Sample 2



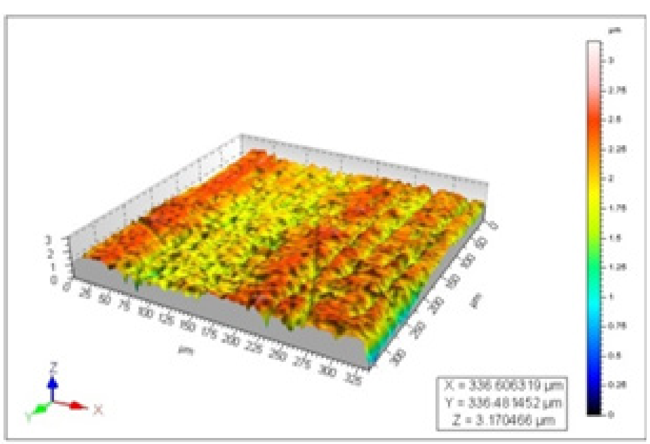
Amplitude parameters - Roughness profile	Mean µm
Ra	0.139959
Rp	0.343157
Rq	0.172446
Rt	1.253779

Fig 13: Optic Profilometer Analysis for Group III a Sample 1



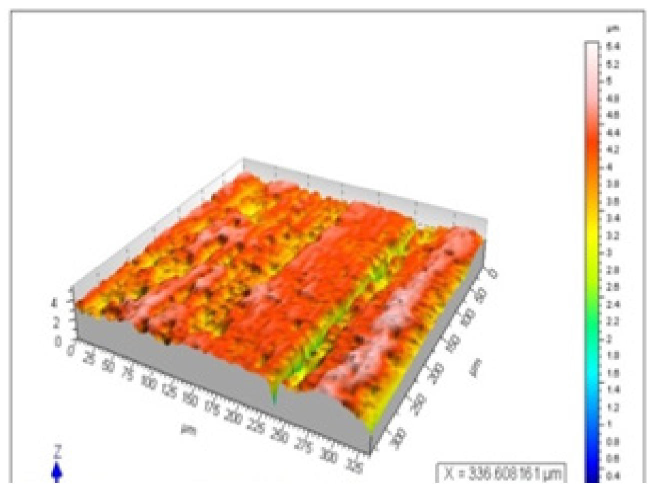
Amplitude parameters - Roughness profile	Mean µm
Ra	0.155740
Rp	0.413427
Rq	0.199119
Rt	1.091508

Fig 14: Optic Profilometer Analysis for Group III a Sample 2



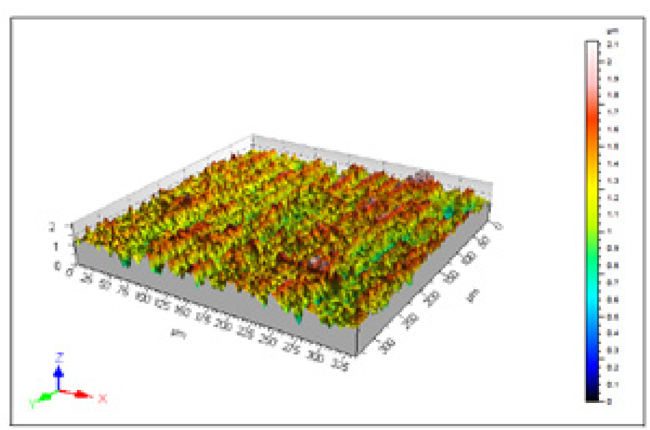
Amplitude parameters - Roughness profile	Mean µm
Ra	0.184574
Rp	0.451380
Rq	0.237969
Rt	1.471677

Fig 15: Optic Profilometer Analysis for Group III b Sample 1



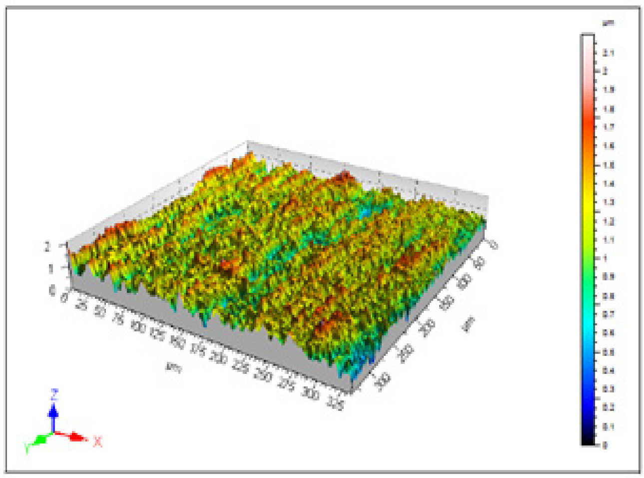
Amplitude parameters - Roughness profile	Mean µm
Ra	0.254513
Rp	0.533695
Rq	0.364955
Rt	2.841504

Fig 16: Optic Profilometer Analysis for Group III b Sample 2



Amplitude parameters - Roughness profile	Mean µm
Ra	0.157717
Rp	0.373388
Rq	0.199061
Rt	1.073696

Fig 17: Optic Profilometer Analysis for Group III c Sample 1



Amplitude parameters - Roughness profile	Mean µm
Ra	0.153429
Rp	0.381193
Rq	0.191525
Rt	0.972673

Fig 18: Optic Profilometer Analysis for Group III c Sample 2

DISCUSSION:

When exposed to oxygen, metal surfaces generate an oxide coating that impedes penetration by an attacking agent. A passivation layer must develop on nickel-titanium wires for them to be resistant to corrosion.

White spot lesions surrounding orthodontic brackets may be prevented or treated by using fluoride preventive agents such as acidulated phosphate fluorides (APF) or neutral fluorides. However, the fluoride ions included in the preservatives may cause corrosion and discoloration of titanium and its alloys, it has been noticed, especially when mechanical contact between brackets and wires causes passivated wire surface breaks[4].

Titanium based alloys are vulnerable to corrosion and hydrogen embrittlement due to exposure to fluoride compounds, which are characterized by an acidic pH.[5]

Despite the fact that polymer-based esthetic wires look great, they have not been widely used in clinical settings because of their fragility. Alternatively, polymer-coated archwires made of metals like Teflon and epoxy resin have been produced.[6]

Several new types of aesthetically pleasing brackets and wires have been introduced in response to the increasing demand for cosmetic orthodontic equipment. Braided and coaxial wires, for example, were developed because of the growing interest in using light forces.

These NiTi braided wires are prefabricated and provide all the benefits of both NiTi and rectangular braided wire. NiTi's already impressive superelastic characteristics are further enhanced by the braiding process. This wire enables early torque control owing to its rectangular cross-section. Its application includes midtreatment second molar engagement and early torque management.[7]

Both the acidulated fluoride agent (Phos-flur gel. Figure 1) and the neutral fluoride agent (Prevident 5000, Figure 2) were shown to have an effect on the surface properties of all three sets of wires. Surface properties were reduced more by the acidulated fluoride agent (Phos-flur gel) than by the other fluoride agent. The results of our study showed similar results to **Shaza M. Hammad et al study**[8] and **KazuyukiKaneko et al** studies.[9-10].

When compared between the three groups of wires, coated NiTi wires (Group 2) showed highest surface roughness, followed by braided NiTi wires (Group 3). Non coated NiTi wires (Group 1) were also affected by both the fluoride agents, but less surface roughness than the others.

Surface irregularities and lack of uniformity in thickness of the coated wires is one of the causes for the damage that has observed in coated NiTi wires (Group 2). As previously stated by **Dayanne Lopes Da Silva et al**[11] in their study. When these wires were immersed in fluoride agents further detrimental surface changes were noted.

Mena Hasan Abdulqader, Sami Kadhum Al-joubori [12] has done study on surface roughness of Teflon coated NiTi wires immersed in fluoridated and non-fluoridated mouth washes. The results of this study are similar to current study that coated NiTi wires immersed in fluoridated mouthwash showed increased surface rou

CONCLUSION

Uncoated Ni-Ti has a rough surface, coated Ni-Ti, and braided Ni-Ti wires all increased significantly after being exposed to either neutral or acidulated preventive fluoride gels.

On comparison between two fluoride agents (acidulated fluoride agent (Phos-flur gel) and neutral fluoride agent (Prevident 5000)), significant changes were observed with acidulated fluoride agent (Phos-flur gel) followed by neutral fluoride agent (Prevident 5000). As a result, was established that fluoride compounds modify orthodontic arch wires' physical characteristics.

Among all three groups, increased surface roughness was observed with coated Ni-Ti wires (group II) followed by braided Ni-Ti wires (group III) and non-coated Ni-Ti (group I).

These results obtained were from an in-vitro study, whereas the oral cavity is complex in nature, the exposure time, salivary pH and the components could give a varied inference. Hence further study and research is a mandate.

References

1. Walker MP, White RJ, Kula KS. Effect of fluoride prophylactic agents on the mechanical properties of nickel-titanium-based orthodontic wires. Am J Orthod Dentofacial Orthop 2005;127:662–669.
2. Kwon YH, Cho H, Noh D, Kim H, Kim K. Evaluation of the effect of fluoride-containing acetic acid on NiTi wires. J Biomed Mater Res Part B: Appl Biomater 2005;72B:102-108.
3. Kim H, Johnson JW. Corrosion of stainless steel, nickel titanium, coated nickel-titanium and titanium orthodontic wires. Angle Orthod1999;69:39–44.
4. Watanabe I, Watanabe E. Surface changes induced by fluoride prophylactic agents on titanium-based orthodontic wires.Am J Orthod Dentofacial Orthop 2003;123:653-6.
5. Yokoyama K et al. Hydrogen embrittlement of work-hardened Ni–Ti alloy in fluoride solutions. Biomaterials 2005: 26:101–108.
6. Sahoo N, Bhuyan L, Dhull KS, Dash KC, MD I, Mishra P. In Vitro Effect Of Fluoride Prophylactic Agents On Titanium Molybdenum Alloy And Stainless Steel Orthodontic Wires – Scanning Electron Microscope Study. Bangladesh J Med Sci. 2023;22(20):47-51.
7. Nessa K, Anwar N, Ghosh R, Mondal S, Alam MK. Utilization of residual space of deciduous second molar to align teeth in a crowded arch. Bangladesh J Med Sci. 2020 Apr;19(4):763-8.
8. Hammad SM, Wakeel EE, Gad ES.Mechanical properties and surface characterization of translucent composite wire following topical fluoride treatment. Angle Orthod 2012;82:8–13.
9. Kaneko K, Yokoyama K, Moriyama K, Asaoka K, Sakai J, Nagumo M. Delayed fracture of beta titanium orthodontic wire in fluoride aqueous solutions. Biomaterials 2003;24:2113-20.
10. Kaneko K, et al. Degradation in performance of orthodontic wires caused by hydrogen absorption during short-term immersion in 2.0% acidulated phosphate fluoride solution. Angle Orthod2004;74:487–495.
11. Dayanne Lopes da Silva: Coating stability and surface characteristics of esthetic orthodontic coated archwires. Angle Orthod. 2013;83:994– 1001.
12. Mena Hasan Abdulqader, Sami Kadhum Al-joubori,Assessment of Surface Roughness of eflon Archwires Immersed in Mouthwashes (An In-vitro Comparative Study), J Res Med Dent Sci, 2022, 10(2):662-668