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Assessment of impact of fluoride on mechanical properties of NiTi and Cu NiTi orthodontic archwires

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***Abstract*---**Background: The current study was carried out to assess the impact on the mechanical properties of orthodontic wires such as the NiTi and CuNiTi wires by fluoride available in various prophylactic products. Materials & methods: 80 wire specimens were selected and were divided into two study groups with 20 specimens in each group as follows": Group A: 0.019 x 0.025 inch NiTi archwires (NT3, American Orthodontics,USA), Group B: 0.019 x 0.025 inch CuNiTi archwires (Tritanium, American Orthodontics,USA). Following fluoride agent was taken as standard for the present study: Phos-Flur gel (Colgate oral pharmaceuticals, New York, USA). From the straight part of the archwire enrolled in the present study, wire specimens of dimensions 0.40 X 0.60 X 20 mm were cut. Control group: 40 specimens consisting of 20 specimens from each wire type; Solution used was deionized water, and Study group: 40 specimens consisting of 20 specimens from each wire group, placed in the Phos-Flur gel.

Random selection of the wires was done followed by testing under universal force testing machine. Results: Among the study groups subjects, mean loading force among group A and group B specimens was 596.1 MPa and 368.4 MPa respectively. While comparing between study group and control group among NiTi wires; significant results were obtained. Also while comparing between study group and control group among CuNiTi wires; significant results were obtained. Conclusion: Following exposure to fluoride agents, NiTi wires and CuNiTi wires are significantly associated with reduced mechanical properties. Hence routine prophylactic use of fluoride agents should be done with utmost precaution among patients undergoing fixed orthodontic treatment.

***Keywords*---**NiTi Wires, Fluoride

Introduction

Nowadays, more and more adults are going for orthodontic treatment, and simultaneously the demand for better esthetics as well as the quality of orthodontic components is also increasing. There seems to be a partial resolution of the current problems with the advent of the more esthetic and pleasing brackets and wires with coating on them.[1]

Optimal oral hygiene and subsequent caries control is by far the most vital factor which proven and successful orthodontic therapy. There can be demineralisation of the tooth enamel and eventual tooth decay owing to compromised and below optimal levels of oral hygiene. The orthodontists must regularly prescribe various formulations possessing fluorides to maintain oral hygiene. Fluoride containing toothpastes and mouthwashes can be some of these products. Fluoride containing mouthwashes are available for daily as well as weekly use with concentrations of .05% and .2% respectively, and they should be advocated by the orthodontists for prevention of tooth decay.[2, 3]

Thus, the orthodontic components such as the wires are supposed to be exposed to the action of fluoride continuously. There seems to be a strong correlation between the corrosion of orthodontic components and the overall acidic concentration of the environment around the buccal cavity and the usage of products containing fluoride such as mouthwashes and toothpastes.[4- 6] Therefore, this current study was carried out to assess the impact on the mechanical properties of orthodontic wires such as the NiTi and CuNiTi wires by fluoride available in various prophylactic products.

Materials & Methods

A total of 80 preformed archwire of dimension 0.019 x 0.025 inch were divided into two groups with 20 specimens in each group as mentioned in Table 1:

Table 1: Distribution of subjects according to specific group

Groups	Sub groups	Number of specimens
Control group	Group A ((NT3, American Orthodontics,USA))	20
	Group B (Tritanium, American Orthodontics,USA)	20
Study group	Group A ((NT3, American Orthodontics,USA))	20
	Group B (Tritanium, American Orthodontics,USA)	20

Phos-Flur gel (Colgate oral pharmaceuticals, New York, USA) was used as standard fluride agent for study group. In experimental Group A & group B were placed in the Phos-Flur gel. (Colgate oral pharmaceuticals, New York, USA). In control Group A & Group B specimen were kept in de-ionized water.

Incubation of control group specimens was done in deionized water at thirty seven degree centigrade in a plastic vial individually. Incubation of study group specimens was done in fluoride-containing agent in a plastic vial individually. After wards, washing-off of the solution was done followed by cleaning. Random selection of the wires was done. From the straight part of the archwire enrolled in the present study, wire specimens of dimensions 0.40 X 0.60 X 20 mm were cut and were tested for loading force by universal force testing machine. All the results were recorded in Microsoft excel sheet and were analysed by SPSS software. Student t test was used for evaluation of level of significance.

Results

Among the control groups subjects, mean loading force among group A and group B specimens was 682.6 MPa and 397.4 MPa respectively. Among the study groups subjects, mean loading force among group A and group B specimens was 596.1 MPa and 368.4 MPa respectively. While comparing between study group and control group among NiTi wires; significant results were obtained. Also while comparing between study group and control group among Cu NiTi wires; significant results were obtained.

Table 2: Loading forces as tested by universal force testing machine

Groups	Sub groups	Mean loading force (MPa)	SD
Control group (Deionised water)	Group A ((NT3, American Orthodontics,USA))	682.6	46.8
	Group B (Tritanium, American Orthodontics,USA)	397.4	21.8
Study group (Phos-Flur gel)	Group A ((NT3, American Orthodontics,USA))	596.1	53.9
	Group B (Tritanium, American Orthodontics,USA)	368.4	29.4

Table 3: Intergroup comparison

Group comparison	t-statistics	p- value
Control group (Group A) Versus Study group (Group A)	-1.225	0.001 (Significant)
Control group (Group B) Versus Study group (Group B)	-1.996	0.002 (Significant)

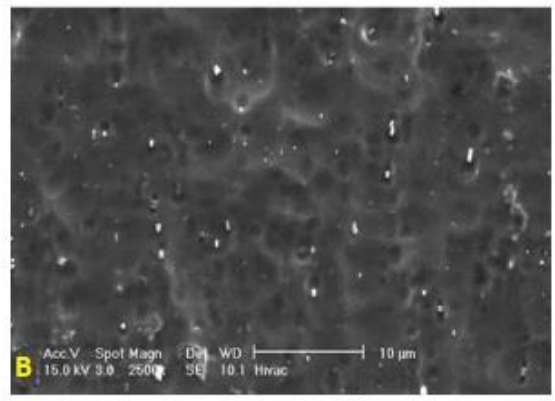

Fig1:SEM of NiTi wires
A-exposed to distill H2O (control)
B-phos-flur gel treated

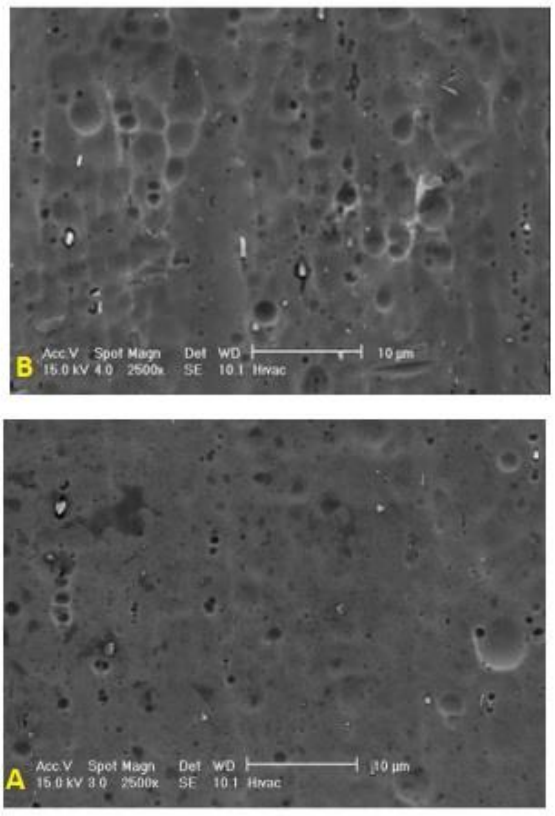

Fig2: SEN of Cu-NiTi wire
A-exposed to distill H2O (control)
B-phos-flur gel treated

Discussion

Orthodontic treatment uses a variety of archwires specified for use at varying stages during the treatment. The ones most commonly used are NiTi and CuNiTi wires for initial levelling and alignment. The less the friction at the interface between the brackets and the archwires, more will be the proficiency of the sliding mechanism. A variety of factors may affect friction. Some of them include the force of contact between the archwires and the brackets, the contact angle

between the two and not to forget the surface properties between the brackets and the archwires. Any change in the surface properties owing to corrosion would eventually lead to an increase in the frictional component thereby reducing the sliding efficiency of archwires on the brackets. A very important role to prevent dental caries has been attributed to fluoride containing products such as toothpastes. In addition to this fluoride containing gels are also commonly prescribed. These products are especially advocated in patients with high caries index and those seeking orthodontic therapy. However, it has been found that hydrofluoric acid is produced is generated as a by product of the interaction between fluoride possessing agents and the hydrogen ions released by the bacterial products. This acid eventually leads to corrosion of the metallic components of orthodontic therapy such as archwires and brackets owing to dissolution of the oxide layer.[7- 9] Hence; this current study was carried out to assess the impact on the mechanical properties of orthodontic wires such as the NiTi and CuNiTi wires by fluoride available in various prophylactic products.

In present study, in the control groups, mean loading force among group A and group B specimens was 682.6 MPa and 397.4 MPa respectively. Among the study groups , mean loading force among group A and group B specimens was 596.1 MPa and 368.4 MPa respectively. Our results were in concordance with the results obtained by Mane et al, who also reported similar findings. In their study, authors assessed the impact on the surface texture of NiTi and CuNiTi wires used in orthodontic therapy by topical fluorides. These preformed wires were kept in an immersed state in fluoride solution and artificially prepared saliva at 37° C for a period of 90 minutes. An optical microscope was thereafter used to assess the effect of these solutions on the surface characteristics of these wires. It was inferred that acidulated preparations containing fluoride were more corrosive than neutral agents. It was thus observed that there needs to be a limitation in the usage of certain fluoride agents during prolonged orthodontic therapy in order to minimise the corrosion of NiTi an CuNiTi wires.[9]

In the present study, while comparing between study group and control group among NiTi wires; significant results were obtained. Also while comparing between study group and control group among CuNiTi wires; significant results were obtained. Similar findings were recorded in the study conducted by Ramalingam et al, In their study, three sample groups with 30 patients each receiving fixed orthodontic treatment were formed. First group did not use any agents containing fluoride, the second group used a fluoride rinse, and the last group used gels containing fluoride. The modulus of elasticity as well as the yield strength of the archwires was assessed after 30 days. The third group showed a significant fall in the modulus of elasticity of the NiTi archwires during unloading. On observing under a scanning electron microscope it was assessed that maximum pitting was seen in the CuNiTi wires which were exposed to gels. It was inferred that there can be a prolongation of orthodontic therapy owing to the deterioration of mechanical properties of NiTi wires due to fluoride use.[10] Močnik P et al had assessed the role of environmental factors on the properties of NiTi and stainless steel products used in dentistry. Cyclic potentiodynamic technique was used to assess the role of pH as well as fluorides on various electrochemical properties. During the study it was seen that lower the pH more is the susceptibility towards corrosion amongst the NiTi alloys. No effect was observed

with minor increase in the fluoride ions concentrations up to 0.024M. However at concentrations of 0.076M, there does seem to be an alteration of the properties. The study observed that after tribocorrosion there was a thicker layer of an oxide film on the surface of NiTi and other steel alloys in contrast with those which were exposed to saliva only.[11]

An in situ experiment was carried out by Abbassy MA et al to assess the impact on the frictional resistance by fluoride application between ceramic and titanium wires. No significant changes were observed in the frictional resistance of the above wires. The buffering effect of the saliva to counter the APF solution as well as the dilution effect was proposed as the explanations for the above mechanism. It was also seen that whenever the orthodontic wires interacted with oral cavity environment, there was an organisation of a noncellular layer on the surface of the materials as a consequence to spontaneous adsorption of certain macromolecules of extracellular nature, predominantly containing glycoproteins and proteoglycans. Therefore, it was noticed that under in situ conditions, the formerly stated reasons lowered the impact of fluoride on NiTi wires.[12-15]

Conclusion

Following exposure to fluoride agents, NiTi (NT3, American Orthodontics,USA) wires and CuNiTi (Tritanium, American Orthodontics,USA)wires are significantly associated with reduced mechanical properties. Hence routine prophylactic use of fluoride agents should be done with utmost precaution among patients undergoing fixed orthodontic treatment.

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