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EFFECTS OF FLUORIDE PROPHYLACTIC AGENTS ON THE MECHANICAL PROPERTIES OF ORTHODONTIC ARCH WIRES- AN INVITRO STUDY

Orthodontics

Dr. Anandu M*	MDS, Reader, Department Of Orthodontics, Vydehi Institute Of Dental Sciences And Research Center, Bangalore, India-560066. *Corresponding Author
Dr. Suchareeta Panda	MDS, Consultant Orthodontics, Coral Dent, Bhubaneshwar, Odisha, India.
Dr. Chetan Shankar	MDS, Professor and Head, Department of Orthodontics, Vydehi Institute of dental sciences and research center, Bangalore, India-560066.
Dr. Vidya Dhari K	MDS, Asst.Professor, Department of Orthodontics, Vydehi Institute Of Dental Sciences And Research Center, Bangalore, India-560066.
Dr.Madhuri Sakarey	MDS, Asst.Professor, Department of Conservative Dentistry and Endodontics, Vydehi Institute of dental sciences and research center, Bangalore, India-560066.

ABSTRACT

Background And Objectives: There are the rising demand for esthetic orthodontic appliances and wires such as braided and co-axial wires. The effect of prophylactic agents on these relatively newly introduced arch wires are scarcely reported. Hence this study was undertaken to assess the effects of prophylactic fluoride agents (1.Acidulated fluoride agent (Phos-flur gel), 2. Neutral fluoride agent (Prevident 5000)on the mechanical 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: Total of 270 specimens of rectangular orthodontic nickel titanium arch wires were selected for this study and divided into three groups. All the three groups of wires (30 each) were immersed in 5 ml of artificial saliva in plastic vials for 2 months (control). No fluoride agents were used in sub-group a. Sub-group b and sub-group c samples were subjected to application of Phos-flur gel and Prevident 5000 respectively, one minute daily for 2 months. All the wires were tested for mechanical properties.

Results: The results of the study showed that the mechanical properties of all the three groups of wires were affected by both acidulated fluoride agent (Phos-flur gel) and neutral fluoride agent (Prevident 5000).

Conclusion: The study results proved that fluoride prophylactic agents (mouthwash or gels) reduce the arch wire properties during orthodontic treatment.

KEYWORDS

Ni-Ti wires, fluorides, elastic modulus, yield strength, spring back ratio, load deflection rate.

INTRODUCTION

Topical fluorides have been used extensively in the prevention of demineralization around orthodontic brackets[1]. The effects of these fluoride agents on conventional archwires such as non- coated Ni-Ti, beta titanium and stainless steel wires have been studied extensively. In recent times, the rising demand for esthetic orthodontic appliances led to the introduction of several esthetic brackets and wires[2]. Also the emphasis on use of light forces has led to the development of alternate wires such as braided and co-axial wires. But there is little information available regarding the effect of prophylactic agents on these relatively newly introduced arch wires.

Hence this study was undertaken to assess the effects of prophylactic fluoride agents (1.Acidulated fluoride agent (Phos-flur gel), 2. Neutral fluoride agent (Prevident 5000)on the mechanical 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

Three rectangular orthodontic nickel titanium preformed arch wires of 0.017 x 0.025 inch were selected for this study. The wires were cut into 25-mm-long specimens from the straight portion of the preformed archwire. Ninety specimens were cut from each type of wire for a total of 270 specimens.

The wires were grouped as follows:
- **GROUP I samples** - 0.017”X0.025” Nickel Titanium archwires (90 specimens).
- **GROUP II samples** - 0.017”X0.025” Coated Ni-Ti archwires (90 specimens).
- **GROUP III samples**- 0.017”X0.025” Braided Ni- Ti archwires (90 specimens).

Each group of archwires were divided into 3 sub-groups:
- **SUB-GROUP a (Control-Artificial saliva)**
- **SUB-GROUP b (Experimental-Phosflur gel)**
- **SUB-GROUP c (Experimental-Prevident 5000)**

All the three groups of wires (30 each) were immersed in 5 ml of artificial saliva in plastic vials for 2 months (control). No fluoride agents were used in sub-group a. Sub-group b and sub-group c samples were subjected to application of Phos-flur gel and Prevident 5000 respectively, one minute daily for 2 months.

Methodology

After immersion and application of fluoride agents for 2 months, all the three group samples were tested for mechanical properties with three point bend test using on a digitally controlled Universal Testing Machine (model:Mecmesin-Multitest 10-I with a load cell of 50kN).

Each specimen was loaded to a deflection of 3.1 mm at a cross-head speed of 1 mm/minute by means of a steel rod with a bibeveled chisel end placed midway between two poles. Flexural modulus of elasticity (E) in megapascals, yield strength (YS) in megapascals and spring back ratio (YS/E) were calculated for each specimen. For load deflection rate, load in Newtons (N) and deflection in millimeters (mm) was collected for loading of each specimen. The data on mechanical properties were analyzed by using a One-way analysis of variance (ANOVA) at 5% level of significance (α =0.05) for loading modulus of elasticity (E) and yield strength (YS) , spring back ratio (YS/E) and load deflection rate for each wire type to find out whether any significant differences among the treatment groups existed. Tukey post- hoc test was used for pairwise comparison of the control group with the experimental groups.

RESULTS

The results of the study showed that the mechanical properties of all the three groups of wires were affected by both acidulated fluoride agent (Phos-flur gel) and neutral fluoride agent (Prevident 5000). ANOVA test showed that there was statistically significant difference on mechanical properties of all the three groups of wires. When compared between two fluoride agents, the mechanical properties were decreased more with acidulated fluoride agent (Phos-flur gel) than neutral fluoride agents (prevedent 5000).

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Modulus Of Elasticity:
Group III (Braided Ni-Ti) wire yielded the highest modulus of elasticity (44040.88 Mpa) followed by Group I (non-coated Ni-Ti wire) (9617.22 Mpa) and Group II (coated Ni-Ti wire) (3634.50 Mpa) (Graph 1). The difference between the Group III wire and other groups showed large difference in modulus of elasticity.

On comparing the mean modulus of elasticity between the three study groups (Sub groups- a.Control(Artificial saliva), b.Phos-flur, c.Prevident 5000) by ANOVA test, there was a statistically significant difference between the 3 sub-groups ($p<0.05$).

Post hoc Tukey test for pairwise comparison between the three study groups. showed that there was statistically significant difference in the modulus of elasticity between the 3 sub- groups.

When compared with the sub-group a (control), the mean modulus of elasticity was decreased more in sub-group b (Phos-flur gel) followed by sub-group c (Prevident 5000)(Graph 2). The sub-group b had more effect on modulus of elasticity in all the three group of wires.

Yield Strength:
On comparing the mean yield strength for the three different wires (Groups) by ANOVA test, there was statistically significant difference between the 3 groups ($p<0.05$) Post hoc Tukey test for pairwise comparison between the three wire groups showed that there was statistically significant difference in the yield strength between the 3 wire groups.

Group III (Braided Ni-Ti) wire yielded the highest yield strength (185.47Mpa) followed by Group I (non-coated Ni-Ti wire)(31.96 Mpa) and Group II (coated Ni-Ti wire)(10.89 Mpa) (Graph 3). The difference between the Group III wire and other groups showed large difference in yield strength.

On comparing the mean yield strength between the three study groups (Sub groups- a.Control (Artificial saliva), b.Phos-flur, c.Prevident 5000) by ANOVA test, there was a statistically significant difference between the 3 sub-groups ($p<0.05$). Post hoc Tukey test for pairwise comparison between the three study groups showed that there was statistically significant difference in the yield strength between the 3 sub- groups.

When compared with the sub-group a (control), the mean yield strength was decreased more in sub-group b (Phos-flur gel) followed by sub-group c (Prevident 5000)(Graph 4). The sub-group b had more effect on yield strength in all the three group of wires.

Spring Back Ratio:
On comparing the mean Spring back ratio for the three Groups by ANOVA test, there was no statistically significant difference between Group I and Group II wires ($p>0.05$). When compared with other groups, Group III (Braided Ni-Ti) wire yielded the highest Spring back ratio (Graph 5). Only Group III (Braided Ni-Ti) wire showed difference in spring back ratio compared to other groups.

Post hoc Tukey test for pairwise comparison between the three wire groups showed that there was no statistically significant difference ($p>0.05$) in the Spring back ratio between Group I and Group II wires. But there was statistically significant difference ($p<0.05$) between Braided Ni-Ti wire and other groups.

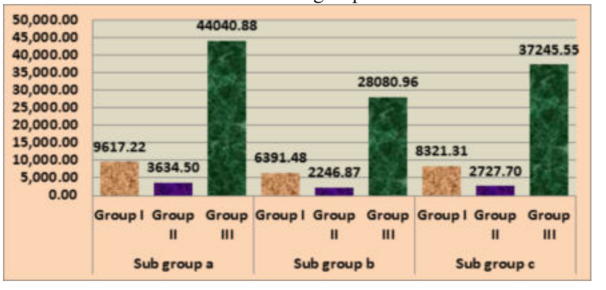
On comparing the mean Spring back ratio between the three study groups (Sub groups- a.Control (Artificial saliva), b.Phos-flur, c.Prevident 5000) by ANOVA test, there was a statistically significant difference between the 3 sub-groups ($p<0.05$). Post hoc Tukey test for pairwise comparison between the three study groups (sub-groups) showed that there was statistically significant difference in the Spring back ratio between the 3 sub- groups.

When compared with the sub-group a (control group), the mean Spring back ratio was decreased more in sub-group b (Phos-flur gel) followed by sub-group c (Prevident 5000)(Graph 6).

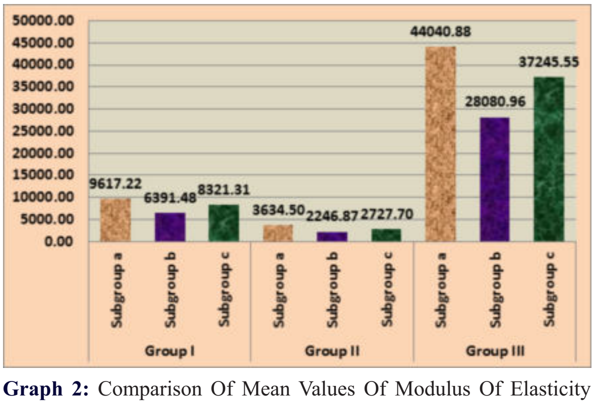
Load deflection rate:
On comparing the mean load deflection rate for the three different wires (Groups) by ANOVA test, there was statistically significant difference between the 3 groups ($p<0.05$) . Post hoc Tukey test for pairwise comparison between the three wire groups showed that there was statistically significant difference ($p<0.05$) in the load deflection rate between the 3 wire groups. Group III (Braided Ni-Ti) wire showed lowest load deflection rate followed by Group II (coated Ni-Ti wire) and Group I (non-coated Ni-Ti wire) (Graph 7).

The difference between the Group III wire and other groups showed large difference in load deflection rate. On comparing the mean load deflection rate between the three study groups (Sub groups- a.Control (Artificial saliva), b.Phos-flur, c.Prevident 5000) by ANOVA test, there was a statistically significant difference between the 3 sub-groups ($p<0.05$). Post hoc Tukey test for pairwise comparison between the three study groups showed that there was statistically significant difference ($p<0.05$) in the load deflection rate between the 3 sub-groups. When compared with the sub-group a (control group), the mean load deflection rate was decreased more in sub-group b (Phos-flur gel) followed by sub-group c (Prevident 5000) (Graph 8).

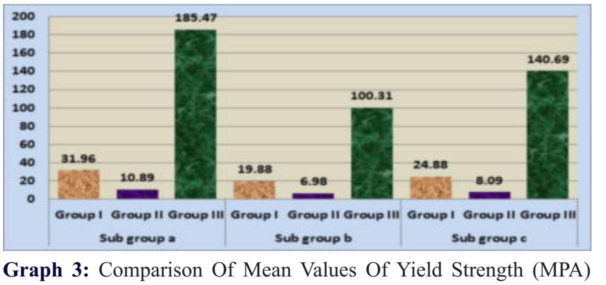
The results of this present study showed that there is a significant effect of fluoride prophylactic agents on the mechanical properties and surface characteristics of all the three groups of Ni-Ti wires.



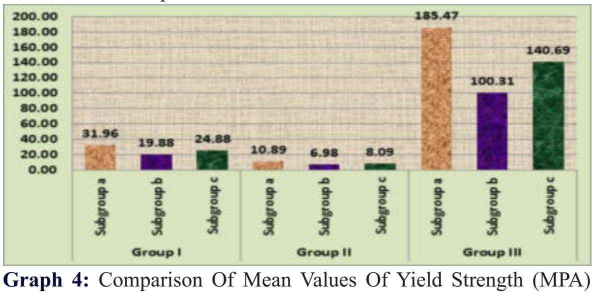
Graph 1: Comparison Of Mean Values Of Modulus Of Elasticity (MPA) Between The Groups



Graph 2: Comparison Of Mean Values Of Modulus Of Elasticity (MPA) Between The Sub-groups

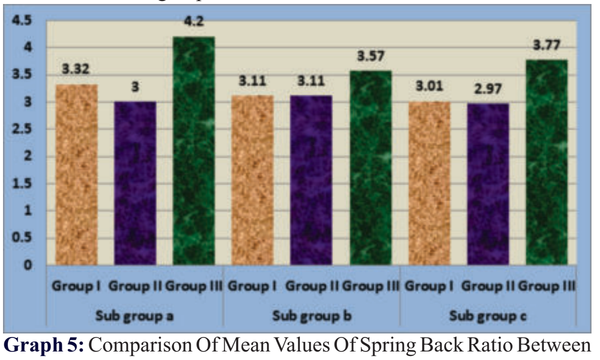


Graph 3: Comparison Of Mean Values Of Yield Strength (MPA) Between The Groups

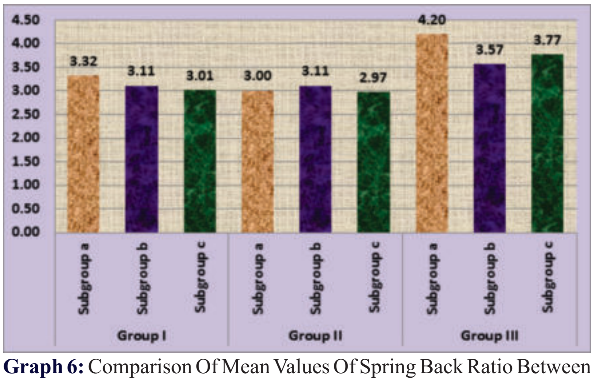


Graph 4: Comparison Of Mean Values Of Yield Strength (MPA)

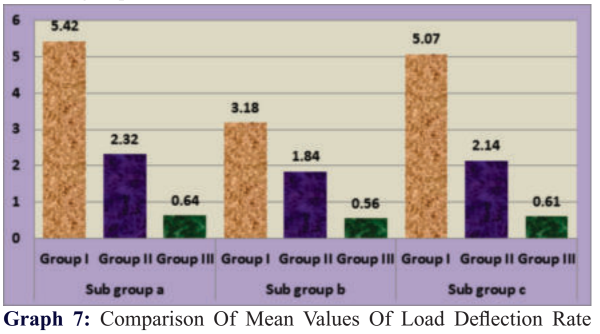
Between The Sub-groups



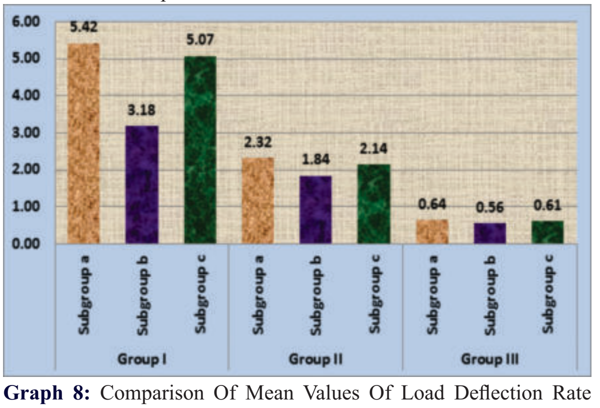
Graph 5: Comparison Of Mean Values Of Spring Back Ratio Between The Groups



Graph 6: Comparison Of Mean Values Of Spring Back Ratio Between The Sub-groups



Graph 7: Comparison Of Mean Values Of Load Deflection Rate Between The Groups



Graph 8: Comparison Of Mean Values Of Load Deflection Rate Between The Sub-groups

DISCUSSION

The corrosion resistance of nickel-titanium wires depends on the formation of a passivation layer, an oxide film.[3] Titanium-based alloys form a passive film of primarily titanium oxides, with titanium dioxide (TiO_2) being the most prevalent.

When titanium based orthodontic wires are exposed to acidulated topical fluoride agents, it is suggested that hydrofluoric acid is produced and it dissolves the protective oxide layer leaving the underlying alloy vulnerable [1].

Acidic pH of fluoride agents is considered an important factor in the breakdown of the titanium-based alloy protective oxide layers leading to fluoride-related corrosion and hydrogen embrittlement.[4]

The results of our study showed similar results to **Shaza M. Hammad et al** [5],and **Mary P.Walker et al**[1]studies. After exposure to either neutral or acidulated prophylactic fluoride gels, all the three group of wires (non-coated Ni-Ti, coated Ni-Ti and braided Ni-Ti wires) showed a statistically significant decrease in loading mechanical properties. When compared between these two fluoride agents, the mechanical properties were decreased more with acidulated fluoride agent (Phos-flur gel) than neutral fluoride agents (Prevident 5000).

CONCLUSION

The study results proved that fluoride prophylactic agents (mouthwash or gels) reduces the arch wire properties during orthodontic treatment. But in clinical situations the exposure may be increased or decreased varying with patients and also content and pH of saliva. Hence a future study is needed

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