Review Article

Effects of Fluoride on Orthodontic Archwires

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Abstract: Orthodontists often prescribe fluoride based prophylactic agents to prevent white spot lesions, which occur due to plaque accumulation around the brackets. However, studies have shown that Orthodontic archwires deteriorate in the presence of fluoride solutions. This article reviews the literature regarding various effects of fluoride on Orthodontic arch wires, such as loading and unloading characteristics, surface topography, corrosion resistance, fracture resistance etc... and its implications.

Key words: Fluoride, Corrosion, Orthodontic archwires,Friction,Surface topography,Fracture resistance.

INTRODUCTION

White spot lesion is a common complication of orthodontic treatment. During orthodontic treatment plaque accumulation around the brackets and the various bacteria in the plaque chiefly streptococcus mutans, lactobacilli may lower the pH of the area due to production of the acid.[1]This may lead to demineralization due to loss of calcium and phosphate. Various studies have demonstrated the effectiveness of fluoride in reducing white spot lesion and so orthodontists often prescribe fluoride based prophylactic agents. [2,3,4,5,6,7,8.] The cariostatic effect of fluoride is due to CaF2.When topical fluoride is applied to the tooth surface, a CaF2 like material build up of plaque or in incipient lesions, which act as a reservoir and release fluoride ions when the pH is lowered during a caries attack.[9]

However, it has been suggested that orthodontic archwires deteriorate in the presence of fluoride solutions. Hydrofluoric acid (HF) is produced in the presence of acidulated topical fluoride agents and it dissolves the protective oxide coating of titanium, leading to corrosion and increased absorption of hydrogen ions. This in turn leads to hybrid phases, particularly titanium hydride. Titanium hydride has been reported to form a body centered tetragonal structure which is considered to be the cause of related degradation of alloy's mechanical properties.[10]

Effect of fluoride on loading and unloading characteristics of Orthodontic archwires: Walker & white[10] conducted a study to assess the effect of fluoride on the mechanical properties of nickel – titanium(Ni-Ti) &copper-nickel-titanium(Cu-Ni-Ti) orthodontic wires.The wires were immersed in acidulated fluoride agent,a neutral fluoride gel or distilled water for 1.5 hrs at 37 deg c.They found that the unloading mechanical properties of Ni-Ti were significantly decreased but not that of Cu- Ni-Ti after exposure to fluoride agents.It has been suggested that the addition of copper to Ni-Ti increases the thermal reactive properties of metal and also act as a relative inhibitor of reducing acids such as HF.[11]

In recent years with increase in adult orthodontics there has been increased use of esthetic wires.Hammad et al[12] conducted a study to assess the effect of fluoride on composite wire(an esthetic wire which consists of glass fibers as reinforcement and a polymer resin as the matrix).It was found that fluoride treatment resulted in statistically significant reduction in flexural modulus of elasticity,yield strength and springback of composite wire.This was attributed to the deteriorating effect of acidic fluoride on the glass fiber present in the composite wire.Also fluoride may cause depolymerization of the matrix filler interface & support filler loss from the matrix.[13]

Ahrari et al[14] compared the load deflection properties of single strand Ni-Ti, multi strand Ni-Ti and Cu-Ni-Ti.He found that unloading forces were significantly lower at 0.5 and 1mm deflections in fluoride treated specimens compared with the control group. In contrast to the above studies Srivastava et al[15] and Perinetti et al[16] observed different results. Srivastava et al[15] in their study found

that phosflur and a neutral sodium fluoride mouthwash didn't affect the mechanical bending properties of Ni-Ti, Cu-Ni-Ti, beta Ti and seals wires in vitro conditions. Perinetti et al[16] evaluated the fracture resistance of two commercially available Ni-Ti based archwires induced by a combination of fluoride, pH & thermocycling.No significant effects in terms of fracture resistance was seen.

Our review of the literature showed that only two in vivo studies have been done in this regard. In the first in vivo study Ramalingam et al[17] exposed patients with fixed appliance to control group, fluoride rinse and fluoride gel groups and concluded that topical agents alter the mechanical properties of Ni-Ti and hence, may prolong orthodontic treatment.

In the second in vivo study Jossette et al[18] studied the effects of a prophylactic fluoride regimen on niti acquires under clinical conditions. They concluded that Wires exposed to fluoride exhibit less force degradation than wires without fluoride exposure at 0.5 mm and 1.0 mm deflection, but they demonstrate a slightly higher force degradation at 3.0 and 3.1 mm deflection.

Effect of fluoride on surface topography of orthodontic archwires: Surface topography plays an important part archwire guided tooth movement. Various studies evaluating the effect of fluoride on orthodontic arch wires have shown its detrimental effect of fluoride on surface topography of orthodontic archwires. Walker & white[10] in their study on effect of fluoride prophylactic agents on orthodontic archwires observed that the surface topography of Cu-Ni-Ti was more severely affected than Ni-Ti. It is seen that copper is not effective at inhibiting surface corrosion. X-ray photon, electron spectroscopy of Cu-Ni-Ti specimen has shown that metallic Cu was enriched at the alloy\oxide interface resulting in increased susceptibility to pitting corrosion[19].

In contrast to the above study Wantable &Watanabe[20] studied the effect of fluoride on (Ni-Ti, Cu-Ni-Ti, Titanium-molybdenum, Titanum-niobium). Scanning Electron Microscope (SEM)showed no significant difference in average surface roughness except Titanium-molybdenum wire which showed significantly higher average surface roughness after immersion in acidulated phosphate fluoride for 24 hrs.The results also suggested that a few applications of APF might change the colour of beta-Titanium alloy wires particularly TMA wire.

In another study it was shown that the acidulated fluoridated agents caused greater corrosive damage as compared to neutral fluoride agents on the surface texture of Ni-Ti and Cu-Ni-Ti archwire.[21] Heravi et al[22] conducted a topographic assessment by SEM showed a pitting corrosion in different shapes in all the wires tested. In both stainless steel and Ni-Ti-1(dentauram) wires, the shape of pits was well-defined; whereas, in the other wires (Ni-Ti-GAC,NiTi-global), the pits were accompanied by fissures and porous surfaces. In a similar study

Lee et al[23] showed that different Ni-Ti had dissimilar corrosion resistance in acidic fluoride containing artificial saliva, which didn't correspond to the variation in surface topography of the archwires. Hammad et al[11] in their study found that composite wire exposed to fluoride demonstrated inhomogenous surface with more irregularities as compared to the control group under SEM. Ni-Ti showed mottled and slightly pitted appearance.SS wire surface appeared rougher and the cracks along the wrought structre were more prevalent &more accentuated as compared to a distilled water control wire.

Effect of fluoride on corrosion resistance of orthodontic archwires: Studies have shown that increase in fluoride ion concentration lead to a decrease in corrosion resistance of orthodontic archwires[18,19].Decrease in corrosion resistance was more on SS wires than in Ni-Ti wires. [18] In another study, Perinetti et al[16] evaluated the surface corrosion of two commercially available Ni-Ti based archwires induced by a combination of fluoride, pH & thermocycling and Significant differences were found.

Galvanic corrosion between orthodontic wires (Ni-Ti and Cu-Ni-Ti) and brackets (Titanium,iron-chromium-nickel ,CoCr)and two commercially available fluoride Elmox, Meridol was assessed by Schiff et al[24].In their study, Niti showed highest corrosion risk in Meridol mouthwash which contains SnF and Cu-Niti showed highest corrosion in Elmex mouthwash which contains NaF.The authors suggested that mouthwash should be advocated according the archwire.

Effect of fluoride on frictional resistance of orthodontic archwires: Friction plays an important role in orthodontics during space closure. Kao et al[25] studied the level of frictional resistance between metal brackets and orthodontic archwires (TMA, Ni-Ti, SSW) after immersion in an APF gel. TMA wire exhibited higher friction. The friction resistance of the wires and brackets increased in the acidic 0.2% APF solution. Alavi & Farahi[26] conducted a study to investigate the effect of fluoride on frictional resistance between SS orthodontic brackets & steel and Ni-Ti archwires.They found that average static & dynamic frictional forces for all bracket wire combinations immersed in sultan fluoride gel (APF 1.23%,pH= 3.5) were higher as compared to NaF(aquafresh mouth wash containing 0.05 % sodium fluoride at pH 5.1) & control group.

Hydrogen absorption behavior of orthodontic wires in fluoride: Yokoyama et al[27] studied the effect of work hardened Ni-Ti alloy in APF.they found that amount of hydrogen absorbed increased linearly with immersion time and also work hardened Ni-Ti alloy is less sensitive to hydrogen embrittlement compared to niti alloy.In a similar study w.r.t to TMA wire,the amount of hydrogen absorbed in 0.2 % increased with time and also it was several times smaller than in 2 % APF[28].In another study kaneko et al[29] showed that the immersion in fluoride solution leads to the degragation beta titanium associated with hydrogen absorption.

Effect of toxicity of fluoride corrosion extracts of orthodontic wires on human osteosarcoma cell line: Kao et al[30] conducted a study to investigate the toxicity of fluoride corrosion extracts of SS and Ni-Ti on a human osteosarcoma cell line (U2OS). They found that SS and NiTi wires in the 0.2%, pH 3.5 NaF artificial saliva group caused a dose-dependent decrease in the survival rate of human osteosarcoma cell line. Our review of the literature showed that there was no other article in this regard.

CONCLUSION: Prophylactic fluoride agents are useful in preventing white spot lesions in orthodontic patients. However, they also have some deleterious effects on orthodontic archwires. They are capable of prolonging the duration of orthodontic treatment thus should be judiciously used. Further research may be carried out in this regard. A new type of prophylactic agent for use during orthodontic therapy could be an important development in this field.

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