

Original Article

Evaluation of Metallic Ion Release from Fixed Orthodontic Appliance in Two Different Mouthwashes and Distilled Water: An In Vitro Study

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Abstract

Objectives: Biocompatibility is an essential requirement for orthodontic appliances, but it leaches metallic ions in the presence of saliva, prophylactic mouthwashes, and toothpaste. This study evaluates the amount of ion release from orthodontic brackets and archwires after immersing them in two different mouthwash and distilled water types.

Methods: Twenty-four orthodontic sets for one mandibular quadrant, including (five brackets), one buccal tube, and a half of the required length of CuNiTi archwires for each set were used. The samples were dipped in Ortho Kin, Kin Forte, distilled water, and measurements were taken at two time points, first after twenty-four hours and second after two weeks. Distilled water was used as the control group. Then the amount of metallic ion release is evaluated by ICP (Inductively Coupled Plasma) spectroscopy.

Results: Results showed that the highest concentration of metallic ion release was from samples containing Ortho Kin mouthwash (fluoridated) then the Kin Forte and distilled water.

Conclusions: Fluoridated mouthwash caused more metallic ion release from orthodontic appliances than non-fluoridated mouthwash and distilled water.

Keywords: *Metallic ions, Mouthwash, Sodium fluoride.*

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Introduction

Intra-orally placed materials manifest a type of continuous response with the environmental agents present in the mouth; that is why they should have definite biological safety and functionality, adequate tissue response, and resistance to corrosion⁽¹⁾.

Corrosion is the process of losing some components from metals. Signs of corrosion include restrained physical changes in metals such as color change and rough surface and chemical changes resulting from the release of metal ions, known as corrosion products, in the surrounding solution⁽²⁾.

Bracket and wire systems are commonly used for orthodontic treatments⁽³⁾. These brackets and wires are made of alloys such as stainless steel, chrome-cobalt-nickel, nickel-titanium⁽⁴⁾. Resistance against corrosion is an essential quality for orthodontic brackets and wires because corrosion can result in the roughness of the appliance, increased friction between the archwire and bracket slot, discoloration of enamel surface adjacent to bracket or wires, and release of ions from the metal or alloy. The release of ions can lead to the discoloration of adjacent soft tissues, cause local pains or cause allergic reactions in susceptible subjects. These ions can also cause cytotoxic and biological side effects^(5,6). These alloys contain nickel which is responsible for the majority of allergic reactions that occur during orthodontic treatments. It is estimated that 2-2.75% of the population are allergic to nickel⁽⁷⁾.

The oral environment is extremely conducive to corrosion and can yield ion release because of the constantly wet mouth environment, constant temperature, and pH change in the mouth. Changes in mouth pH may be influenced by mouthwashes containing fluoride and chloride, which causes the oral environment to become acidic and produces the corrosion process that results in the release of ions⁽²⁾. It was only aimed at, but one of the reviewers asked for our study and the aim, so we add it.

This study aimed to measure the levels of metal ions released from the orthodontic appliance after immersion in two different types of mouthwash that are commonly used for orthodontic patients and distilled water. The result should help practitioners to decide which mouthwash to prescribe for their patients.

Materials and methods

The sample includes twenty-four similar orthodontic set, each one represents half mandibular fixed orthodontic appliance from (central incisor to the first molar) that composed of five stainless steel brackets

(Roth slot 0.022) and one stainless steel buccal tube and a piece of required length (3.5 cm) long (0.019 X 0.025") Cu-NiTi archwire, and Orthometric, Brazil, made all. Each piece of the appliance was cleaned with acetone from dirt and stain, which is volatile and evaporates quickly, rinsed with distilled water, and dried in the air for about 30 minutes^(8,9). The twenty-four set up appliances were divided into three groups (containing eight sets in each group) as follows:

Group A: brackets and archwires immersed in 30 ml of Ortho Kin mouthwash (Kin Company, Spain) in a closely packed screw-topped plastic container.

Group B: brackets and archwires immersed in 30 ml of Kin Forte mouthwash in a closely packed screw-topped plastic container.

Group C: brackets and archwires immersed in 30 ml of distilled water in a closely packed screw-topped plastic container (this group used as a control group).

Then each appliance was set in groups A, B, and C placed in an incubator at 37° C for twenty-four hours and two weeks, respectively. Four containers (set up) from each group were randomly chosen and removed from the incubator at each time interval. The brackets and wires were removed from the solutions using a plastic tweezer, and then one drop of 65% nitric acid was added to fix the released metallic ions. Calibration was done by measuring the number of ions leached using ICP (Inductively Coupled Plasma) spectroscopy in Garmyan University. Samples prepared as stated in materials and methods then placed inside the spectroscopy to calibrate automatically.

Statistical analysis

The statistical analysis was done using SPSS (Statistical Packages for Social Science) program version 22. A one-way ANOVA test was used to analyze the differences in mean ion release between three groups. Independent t-test was used for two groups comparison (Ortho Kin/distilled water, Kin Forte/distilled water, and Ortho Kin/Kin Forte) at 24 hours and two weeks. P-value of ($p \leq 0.05$) was considered statistically significant.

Results

The results showed the release of the (Cu, Ni, Fe) ions from orthodontic brackets and archwires in Ortho Kin, Kin Forte mouthwashes, and distilled water at two-time points (twenty-four hours and two weeks), respectively. For Cr ions, there was no release neither in

mouthwashes nor in the distilled water at two-time points. All comparisons are shown in Tables (1-5).

For Cu ions, a significantly larger amount of ions was released when Ortho Kin was used; however, a significant difference was detected between both types of mouthwash and distilled water after two weeks of immersion, but still higher in Ortho Kin.

A comparison of Ni ions concentration from different fluids showed that the highest amount was in Ortho Kin after two weeks, but the Ni ions release was the same from the three fluids after twenty-four hours.

The concentration of Fe ions released in samples containing Ortho Kin was greater than the released amount in samples with Kin Forte and distilled water at two-time intervals (twenty-two hours and two weeks).

Table 1: composition of mouthwashes used in this study.

Ortho Kin	Kin Forte
Sodium fluoride (226 ppm)	Chlorhexidine digluconate 0.05
Cetylpyridinium chloride	Triclosan
Pro-Vitamin B5	Zinc lactate
Vitamin E acetate	

Table 2: Comparison of mean metal ion concentrations (mg/l) in two groups after 24 hours

24 Hours			
Ions	Group C	Group B	p-value
Cr	zero	zero	-
Cu	0.0013	0.0003	0.101
Fe	0.0026	0.0005	1
Ni	0.008	0.0056	0.102
Ions	Group C	Group A	p-value
Cr	zero	zero	-
Cu	0.0013	0.023	0.004
Fe	0.0026	0.02	0.001
Ni	0.008	0.0063	0.082
Ions	Group B	Group A	p-value
Cr	zero	zero	-
Cu	0.0003	0.023	0.003
Fe	0.0026	0.0206	0.0001
Ni	0.0056	0.0063	0.538

Table 3: Comparison of mean metal ion concentrations (mg/l) in two groups after two weeks.

Two weeks			
Ions	Distilled Water	Kin Gingiva	p-value
Cr	-0.0103	-0.011	0.387
Cu	0.013	0.0133	0.649
Fe	0.0083	0.011	0.075
Ni	0.0073	0.0073	1
Ions	Distilled Water	Kin Ortho	p-value
Cr	-0.0103	-0.01	0.649
Cu	0.013	0.0336	0.0001
Fe	0.0083	0.0283	0.001
Ni	0.0073	0.0146	0.002
Ions	Kin Gingiva	Kin Ortho	p-value
Cr	-0.011	-0.01	0.288
Cu	0.0133	0.0336	0.001
Fe	0.011	0.0283	0.0001
Ni	0.0073	0.0146	0.02

Table 4: Comparison of mean metal ion concentrations (mg/l) in all three groups after 24 hours.

24 hours				
Ions	Distilled Water	Kin Gingiva	Kin Ortho	p-value
Cr	-0.0103	-0.0106	-0.0093	0.068
Cu	0.0013	0.0003	0.023	0.0001
Fe	0.0026	0.0026	0.0206	0.0001
Ni	0.008	0.0056	0.0063	0.096

Table 5: Comparison of mean metal ion concentrations (mg/l) in all three groups after two weeks.

Two weeks				
Ions	Distilled Water	Kin Gingiva	Kin Ortho	p-value
Cr	-0.0103	-0.011	-0.01	0.422
Cu	0.013	0.0133	0.0336	0.0001
Fe	0.0083	0.011	0.0283	0.0001
Ni	0.0073	0.0073	0.0146	0.001

Discussion

- Inductively coupled plasma/ optical emission spectrometry (ICP- OES ARCOS) was used.
- It is a technique in which the composition of elements in (mostly water-dissolved) samples can be determined using plasma and a spectrometer. The technique has been commercially available since 1974; it has become widely applied in both routine research as for more specific analysis purposes.

Ortho Kin contains sodium fluoride (226 ppm). Since it releases high quantities of fluoride, it might result in a breakdown of bacterial cell membrane and denaturation of the protein. Kin Forte composed of chlorhexidine digluconate 0.05%, which is positively charged, will interact with the negatively charged groups on the cell wall and allow the agent to infiltrate in the cytoplasm and cause the death of bacteria⁽¹⁰⁾.

Our results showed that the highest concentration of metallic ion release was from samples containing Ortho Kin mouthwash (fluoridated) than Kin Forte and distilled water. This could be attributed to the fact that both stainless steel orthodontic brackets and CuNiTi archwires are more susceptible to local pitting and corrosion in halides. Aggressive ions present in the solution (fluoride) can lead to the formation of an acid (hydrofluoric acid) which can infiltrate through the undermined areas of a passive film and lead to regional breakdown and starting of corrosion. This corrosion failure cannot be seen by the naked eye but by microscopic observation^(11,12). A similar result is obtained by Kaneko et al. and Shibata et al.^(13,14). Another point to consider is that the acidic pH of fluoride is regarded as a significant point in the split-of the titanium-based alloy protective oxide layer, resulting in fluoride relating corrosion^(15,16).

The results also reveal no significant difference in metallic ion release between Kin Forte mouthwash and distilled water at two-time intervals (twenty-four hours and two weeks, respectively). This is because chlorhexidine mouthwash does not influence the protective oxide coating⁽⁸⁾, and this an agreement with Nik et al.⁽¹⁷⁾. however, this is not in accordance with the study conducted by Gajpurada et al.⁽¹⁰⁾; they studied the ion release from 120 orthodontic stainless steel brackets immersed in four different solutions for forty-five days, higher ion release was found with chlorhexidine when compared to other mouthwashes.

Our study was within 2 weeks' interval and we cannot extend it to 45 days like the last study that disagrees with our result. Also, the type of mouthwashes company we used differed from the one they used in their study. And the only limitation that we face was that we don't have ICP spectroscopy in our university, and communication was somewhat difficult with Garmyan university.

Conclusion

It can be reason out that the resulting ion leach from orthodontic appliance dipped in mouthwashes has a little value which is lower than the limit of daily consumption of (Cr, Ni, Cu, Fe) ions by the world health organization.

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