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Salivary Electrolytes in Patients Undergoing Fixed Orthodontic Treatment

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Abstract

Background and Objective: The base metal alloys are more susceptible to corrosion than noble alloys and fixed orthodontic appliances are generally made of base alloys. Fixed orthodontic appliances in oral cavity are exposed to destructive physical and chemical agents which may result in metallic corrosion**.** The aim of present study was to evaluate the concentration of cobalt, zinc and magnesium in saliva of patients with fixed orthodontic appliance at three different times.
Subjects and Methods: Saliva samples from 18 patients (9 males and 9 females) between 15-25 years were taken at three different time points, Group I: Pre-treatment saliva sample, group II: one month after appliance placement, Group III: four months after appliance placement. The fixed appliance consists of 20 stainless steel brackets, 4 buccal tubes, and super elastic nickel-titanium arch wire. Level of ions in salivary samples was analyzed by Inductively Coupled Plasma Optical Emission Spectrometry. Ions recorded in parts per billion. Statistical analysis was performed by nonparametric tests (Friedman) and one-way repeated measures ANOVA.
Results: Level of cobalt, magnesium and zinc ions in saliva were highest in group II, lowest in group I for both zinc and cobalt while lowest in group III for magnesium. On a pairwise comparison between different groups, it was statistically significant for all groups (< 0.005) except for cobalt and magnesium level between group I and group III and for zinc level between group II and group III.
Conclusion: Cobalt, magnesium and zinc level in saliva were increased after the placement of fixed orthodontic appliance.

Keywords: Saliva; Orthodontic appliance; Electrolyte.

1. Introduction

Base metal alloys are more susceptible to corrosion than noble alloys and fixed orthodontic appliances are generally made of base alloys [1], these fixed orthodontic appliances in oral cavity are exposed to destructive physical and chemical agents which may result in metallic corrosion. Abrasion by tooth brushes, liquids and foods, and leads, to the release of ions which in sequence causes corrosion of these alloys, as the combinations different metal alloy are used for numerous periods in orthodontic patients and distinctive attention should be given to their biocompatibility [2]. The biodegradation of orthodontic appliances has become a critical issue due to its high potential of ionic release, in the oral cavity various factors promote the biodegradation of orthodontic appliances thus leads to corrosion. The enzymatic and microbial activity, several chemicals that contact with oral cavity through food and drink and the change of pH and temperature are all corrosion conductors [3]. Assessment of releasing potential of fixed orthodontic appliances may be influenced by time, releasing

of cobalt chromium alloys can be measured after a short time in in-vivo studies [4, 5]. In oral environment, saliva serves as an electrolyte which additionally promotes metal ion conduction. Each metal alloy has capability of intrinsic heterogeneity and its usage with other alloys, the quantity of forces that acts on the appliances and the friction between wires and brackets, irregularity of micro surface furthermore enhance the corrosion process [6]. Releasing of metal ions does not straight depend on the quantity of each metal in the alloy and some alloys are generally more resistant to corrosion [7]. some components released as a result of corrosion, these components can cause biological problems after being absorbed by the body [8]. The aim of present study was to evaluate the concentration of cobalt, zinc and magnesium in saliva of patients with fixed orthodontic appliance at three different times, before appliance placement, one and four months after appliance placement.

2. Material and Methods

2.1 Sample size: Present study and the informed consent form were approved by the ethics committee of the College of Dentistry, written informed consent was obtained from all participants. The sample size consisted of 18 subjects (9 females and 9 males), ranging from 15 to 25 years of age, with an average age of 17.5 years. Salivary samples were taken from patients who were treated using fixed orthodontic appliances with different malocclusion, fixed orthodontic appliances consist of 20 stainless steel brackets (equilibrium® 2 "Roth 0.022", DENTARUM Ispringen, Germany) figure 1 stainless steel Buccal tube (Ortho-Cast M-Series, non-convertible, DENTARUM, Ispringen, Germany), upper and lower nickel-titanium arch wires (Super elastic, 0.12, 0.14, 0.16, 0.18 rematitan® "LITE" ideal arch, round, DENTARUM, Ispringen, Germany).

2.2 Design of study: Patients were selected based on absence of any metal restorations or pervious orthodontic treatment, patient in the permanent dentition stage with good health and absence of prolonged use of any medication, absence of any systemic disease. The unstimulated saliva of these 18 patients was collected at different time intervals, that is, before placement of appliance, after 1 month and 4 months of placement of appliance. Thus, a total of 54 saliva samples were obtained which were divided into three groups: Group I: Pre-treatment saliva sample Group II: Saliva sample after 1-month Group III: Saliva sample after 4 month. Patients were requested to use non-fluoridated one type and one brand of toothpaste for brushing during the study period. Patients were also told to remain fast in their visit's morning until the sampling time. They were given written and oral instructions for hygiene maintenance[9].

Figure 1. Buccal tubes for first molars **(A),** Stainless steel brackets **(B).**

2.3 Saliva collection

Salivary samples have been taken between 9 a.m. and 12 noon, at least 2 hours after oral hygiene procedures in order to minimize the effects of diurnal variability in salivary composition, 11 sample collection have been carried out such that, after rinsing with 15 ml of distilled and deionized water for 30 seconds, after that each subject asked to rest and close his or her mouth for 5 minutes in order to collect saliva in his or her mouth without any stimulation, after 5 minutes each subject asked spitting 5 ml of saliva directly into 10 ml sterilize polypropylene tube.

The samples were kept at −20 °C until they were processed and diluted with deionized water to eliminate interference and to reduce the effects of the biological matrix (protein, salt, etc.) as described by Dwivedi, et al[10]. Salivary samples were analyzed by Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES ARCOS), concentration of cobalt, magnesium and zinc have been recorded in Nano gram per milliliter equal to parts per billion (ppb). The analyzing of salivary samples has been carried out at Ministry of Higher Education and Scientific Research University of Garmian Advisory office for analysis.

2.4 Statistical Analysis

The statistical analysis has been done by using Statistical Package for Social Sciences (SPSS) version 22.0 statistical analysis software, descriptive statistics were calculated including mean, standard deviation, the shapiro-wilk normality test was applied to data to check normality, cobalt was not normally distributed so the non-parametric Friedman test used to show the cobalt concentration with in subjects in different time points when the result of Friedman test was significant then the post hoc Wilcoxon test applied in order to compare between two time points, zinc and magnesium were normally distributed so the one way repeated measures ANOVA used to show the presence of difference of zinc and magnesium with in subjects in different time points then post hoc test applied to compare between two time points of zinc and magnesium level in saliva, p value < 0.05 was considered significant.

3. Result

Table 1 shows the level of cobalt in saliva in different groups, where it was found highest in group II and lowest in groups I. On comparison of cobalt level in saliva among different groups [Table 1], it was found statistically significant for all the groups except between group I and group III (P≤0.05).

Table 1. Descriptive statistics and comparison of salivary cobalt level (ppb) at three time points by Friedman test

Groups	Mean	St. Deviation
I: Pre-treatment cobalt	<DL*	<DL*
II: cobalt after 1 month	1.44	1.05
III: cobalt after 4 month	0.05	0.23

Comparison of groups		Sig.
I: Pre-treatment cobalt	II: cobalt after 1 month	0.000
I: Pre-treatment cobalt	III: cobalt 4 after month	0.317
II: cobalt after 1 month	III: cobalt 4 after month	0.000

<DL* = non-detectable, P value ≤0.05 considered significant

Table 2 & 3 shows the level of Magnesium and Zinc in saliva in different groups, where it was found highest in group II for both ions and lowest in groups I for zinc and lowest in groups III for Magnesium. On comparison of Magnesium and Zinc level in saliva among different groups [Table 2 & 3], it was found statistically significant for all the groups except between group I and group III for magnesium and between group II and group III for zinc ($P \leq 0.05$).

Table 2. Descriptive statistics and comparison of salivary Magnesium level (ppb) at three time points by repeated measure ANOVA test

Groups	Mean	St. Deviation
I: Pre-treatment Magnesium	4021.16	1781.37
II: Magnesium after 1 month	10125.05	3993.02
III: Magnesium after 4 months	3224.27	1097.54

Comparison of groups		Sig.
I: Pre-treatment Magnesium	II: Mg after 1 month	0.000
I: Pre-treatment Magnesium	III: Mg 4 after month	0.079
II: Magnesium after 1 month	III: Mg 4 after month	0.000

P value ≤0.05 considered significant

Table 3. Descriptive statistics and comparison of salivary Zinc level (ppb) at three time points by repeated measure ANOVA test

Groups	Mean	St. Deviation
I: Pre-treatment Zn	32.33	24.92
II: Zn after 1 month	281.11	245.63
III: Zn after 4 months	189.72	172.88

Comparison of groups		Sig.
I: Pre-treatment Zn	II: Mg after 1 month	0.001
I: Pre-treatment Zn	III: Mg 4 after month	0.001
II: Zn after 1 month	III: Mg 4 after month	0.165

P value ≤0.05 considered significant

4. Discussion

Orthodontic appliances have ability of releasing metal ions in the oral environment because most of orthodontic appliances are made of stainless steel and nickel titanium alloys. The corrosion of orthodontic appliances and their subsequent metal ion release in the oral environment is governed by two main factors. The first is the manufacturing process, which includes the type of alloy and the characteristics of the metals used the second is environmental factors, such as mechanical stress, diet, time of the day, salivary flow rate, and health and psychosomatic condition of the individual[11]. In general the results in present study indicated that there were over all significant increase of salivary cobalt, zinc and magnesium level of orthodontic patient after fixed orthodontic appliance placement, release of salivary cobalt was non-detectable at pretreatment then increase one month after appliance placement which was 1.44 ppb then decrease at four month after appliance placement which was .05

ppb. The release of salivary magnesium was 4021.16 ppb at pretreatment then increase one month after appliance placement which was 10125.05 ppb then decrease at four month after appliance placement which was 224.27 ppb. The release of salivary zinc was 32.33 ppb at pretreatment then increase one month after appliance placement which was 281.11 ppb then decrease at four month after appliance placement which was 189.72 ppb.

Results of present study indicated that the cobalt levels in saliva at one month after fixed appliance placement (group II) was significantly higher than pretreatment (group I), but there was no statistically significant difference cobalt level in saliva between pretreatment (group I) and four months after fixed appliance placement (group III) this findings in accordance with study done Jurela et al[12] they reported non-statistically significant difference of cobalt level in saliva six months after fixed appliance placement as compared with pretreatment levels. While dissimilar with study reported by Shetty et al[3] [13] they found statistically significant difference of cobalt level in saliva three months after fixed appliance placement when compared with pretreatment level.

In present study level of magnesium in saliva at one month after fixed appliance placement (group II) was significantly higher than pretreatment level (group I), Arash et al[1] reported similar result with present study regarding the statistically significant difference of magnesium level in saliva between pretreatment and one month after fixed appliance placement while Arash et al. in the same study reported dissimilar results with present study they found statistically significant difference of magnesium six months after fixed orthodontic appliance as compared with pretreatment magnesium level, as in present study there was non-statistically significant difference of magnesium level four months after fixed orthodontic appliances when compared with pretreatment level of magnesium. In the present study level of zinc in saliva at one month after fixed appliance placement (group II) was significantly higher than pretreatment level (group I) and level at four months after fixed appliance placement (group III). Similar results with the present study reported by Jurela et al [12], they reported statistically significant increase of zinc level in saliva six months after fixed orthodontic appliance placement when compared with pretreatment level. The difference between results of present study with these studies might be due to the effect of many factors such as difference in temperature, quality and quantity of saliva, plaque, proteins and physical and chemical properties of diet taken and also might be due to different methods for analyzing the levels of the metal ions in saliva or sample selection.

Conclusion

Cobalt, magnesium and zinc level in saliva were significantly increased after the placement of fixed orthodontic appliance but then gradually decreased. Also, Maximum level Cobalt, magnesium and zinc ions in saliva were found after one month of fixed orthodontic appliance placement.

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