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Salivary Electrolytes in Patients Undergoing Fixed Orthodontic Treatment

Bayan Abdulla Hassan*

Pedodontics, Orthodontics, Preventive Dentistry (P. O. P) Department, College of Dentistry, Hawler Medical University, Erbil, Iraq

Abstract: The base metal alloys are more susceptible to corrosion than nobl ealloys, and fixed orthodontic appliances are generally made of base alloys. Fixed orthodontic appliances in the oral cavity are exposed to destructive physical and chemical agents, resulting in metallic corrosion. The present study aimed to evaluate the concentration of cobalt, zinc, and magnesium in patients' saliva with fixed orthodontic appliances at three different times. Saliva samples from 18 patients (9 males and 9 females) between 15-25 years were taken at three different time points. Group I: Pretreatment 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 a super elastic nickel-titanium arch wire. Inductively Coupled Plasma Optical Emission Spectrometry analyzed the level of ions in salivary samples. Ions are recorded in parts per billion. Statistical analysis was performed by non-parametric tests (Friedman) and one-way repeated measures ANOVA. Levels of cobalt, magnesium, and zinc ions in saliva were highest in group II, lowest in group I for both zinc and cobalt, and lowest in group III for magnesium. On a pair wise 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 zinc level between groups II and III. Cobalt, magnesium, and zinc levels in saliva were increased after placing a fixed orthodontic appliance.

Keywords: saliva, orthodontic appliance, electrolyte.

接受固定正畸治疗的患者的唾液电解质

摘要：贱金属合金比贵合金更容易腐蚀，**固定式正畸**矫治器一般由贱合金制成。**口腔中的固定正畸**矫治器暴露于破坏性的物理和化学试剂，导致金属腐蚀。**本研究旨在**评估三个不**同**时间使用固定正畸矫治器的患者唾液中钴、锌和镁的浓度。**在三个不同的**时间点采集了 15 **至** 25 岁之间的 18 **名患者**（9 **名男性和** 9 **名女性**）**的唾液**样本。**第** I 组：预处理唾液样本，**第** II 组：**放置**矫治器后 1 **个月**，**第** III 组：**放置**矫治器后 4 **个月**。**固定**矫治器由 20 **个不**锈钢托槽、4 **根**颊管和一根超弹性镍钛弓丝组成。电感耦合等离子体发射光谱法分析了唾液样本中的**离子水平**。**离子的**记录单位为十亿分之几。**通**过非参数检验（**弗里德曼**）**和**单向重复测量方**差分析**进行统计分析。**唾液中**钴、镁和锌离子的含量在第 II 组中最高，**在第** I 组中锌和钴含量**最低**，**在第** III 组中最低。**在不同**组之间的成对比较中，**除了第一**组和第三组之间的钴和镁**水平以及第二**组**和第三**组之间的锌水平之外，**所有**组都具有统计学意义（<0. 005）。**放置固定正畸**矫治器后，**唾液中的**钴、镁和锌含量增加。

关键词：**唾液**、**正畸器具**、电解液。

1. Introduction

Base metal alloys are more susceptible to corrosion than noble ones, and fixed orthodontic appliances are generally made of base ones [1]. These fixed orthodontic appliances in the oral cavity are exposed to

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About the authors: Bayan Abdulla Hassan, Pedodontics, Orthodontics, Preventive Dentistry (P. O. P) Department, College of Dentistry, Hawler Medical University, Erbil, Iraq

Corresponding author Bayan Abdulla Hassan, bayan.hassan.@hmu.edu.krd

destructive physical and chemical agents, which may result in metallic corrosion. Abrasion by tooth brushes, liquids, and foods leads to the release of ions, which causes corrosion of these alloys. The combinations of different metal alloys aroused for numerous periods in orthodontic patients, and exceptional attention should be given to their biocompatibility [2]. The biodegradation of orthodontic appliances has become a critical issue due to its high potential for ionic release; in the oral cavity, various factors promote the biodegradation of orthodontic appliances, thus leading to corrosion. The enzymatic and microbial activity, several chemicals that contact with oral cavity through food and drink, and the change in pH and temperature are all corrosion conductors [3]. Assessment of releasing the potential of fixed orthodontic appliances maybe influenced by time; releasing of cobalt-chromium alloys can be measured after a short time in in-vivo studies [4, 5]. In the oral environment, saliva serves as an electrolyte that promotes metal ion conduction. Each metal alloy has the capability of intrinsic heterogeneity and its usage with other alloys, the number of forces that act on the appliances and the friction between wires and brackets, irregularity of micro surface, and enhance the corrosion process [6]. Releasing 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]. However, some components are released due to corrosion; these componentscan causebiological problems afterbeing absorbed by the body [8, 9]. The present study aimed to evaluate the concentration of cobalt, zinc, and magnesium inpatients' saliva with a 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

The present study followed the guidelines of the Consolidated Standards of Reporting Trials statement [10], and the ethics committee approved the informed consent form of the College of Dentistry. In addition, 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, with an average age of 17. 5 years. Salivary samples were taken from patients 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). Fig. 1 shows stainless steel Buccal tube (Ortho-Cast M-Series, non-convertible, DENTARUM, Ispringen, Germany), upper and lower nickel-titanium arch wires (Superelastic, 0.12, 0.14, 0.16, 0.18 rematitan® “LITE” ideal arch, round, DENTARUM, Ispringen, Germany).

2. 2. Design of the Study

Patients were selected based on the absence of any metal restorations or previous orthodontic treatment, patients in the permanent dentition stage with good health and the absence of prolonged use of any medication, and the absence of any systemic disease. The unstimulated saliva of these 18 patients was collected at different time intervals, that is, before the appliance placement, after 1 month, and 4 months. Thus, 54 saliva samples were obtained, which were divided into three groups: Group I: Pretreatment saliva sample Group II: Saliva sample after1-month Group III: Salivasampleafter4months. Patients were requested to use non-fluoridated type and one brand of toothpaste for brushing during the study period. Patients were also told to remain fast during their morning visit until the sampling time. In addition, they were given written and oral instructions for hygiene maintenance [11].

Fig. 1 Buccaltubes for first molars (A), Stainless steel brackets (B)

2. 3. Saliva Collection

Salivary samples have been taken between 9 and 12 a.m., at least 2 hours after oral hygiene procedures, to minimize the effects of diurnal variability in salivary composition. 11 sample collections have been carried out that way. After rinsing with 15ml of distilled and

deionized water for 30 seconds, each subject was asked to rest and close their mouth for 5 minutes to collect saliva in the mouth without any stimulation. After 5 minutes, each subject was asked to spit 5ml of saliva directly into a 10 ml sterilized polypropylene tube.

The samples were kept at -20°C until they were processed and diluted with deionized water to eliminate interference and reduce the effects of the biological matrix (protein, salt, etc.) as described by Dwivedi et al. [12]. Salivary samples were analyzed by Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OESARCOS); cobalt, magnesium, and zinc concentrations were recorded in Nanogram per milliliter equal to parts per billion (ppb). The analysis of salivary samples has been carried out at the Ministry of Higher Education and Scientific Research University of Garmian Advisory office.

2.4. Statistical Analysis

The statistical analysis was done using Statistical Package for Social Sciences (SPSS) version 22.0. 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. Hence, the non-parametric Friedman test was used to show the cobalt concentration within subjects at different time points when the result of the Friedman test was more significant than the post hoc Wilcoxon test applied to compare two time points.

Zinc and magnesium were typically distributed, so the one-way repeated measures ANOVA was used to show differences in Zinc and magnesium within subjects at different time points. Then post hoc test was applied to compare two time points of Zinc and magnesium levels 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 to be highest in group II and lowest in group I. On comparison of cobalt levels in saliva among different groups (Table 1), it was found to be statistically significant for all the groups except 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

Comparison of groups		Sig.
I: cobalt pretreatment	II: cobalt after 1 month	0. 000
I: cobalt pretreatment	III: cobalt after 4 month	0. 317
II:cobaltafter 1 month	III: cobalt after 4 month	0. 000
Groups	**Mean**	**St. Deviation**
I:cobalt pretreatment	<DL*	<DL*
II:cobaltafter1 month	1. 44	1. 05
III:cobaltafter4 month	0. 05	0. 23

<DL*=non-detectable, Pvalue≤0. 05consideredsignificant

Tables 2 & 3 show the level of Magnesium and Zinc in saliva in different groups, where it was found to be highest in group II for both ions and lowest in group I for Zinc and lowest in group III for Magnesium. On comparison of Magnesium and Zinc levels in saliva among different groups (Tables 2 & 3), it was found statistically significant for all the groups except group I and group III for magnesium and between group II and group III for zinc (P≤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: Magnesium Pretreatment	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: Magnesium Pretreatment	II: Mg after 1 month	0. 000
I: Magnesium Pretreatment	III: Mg 4 after month	0. 079
II: Magnesium after 1 month	III: Mg4 after month	0. 000

P-value ≤ 0. 05 is 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: Mg4 aftermonth	0. 165

P-value ≤ 0. 05 is considered significant

4. Discussion

Orthodontic appliances can release metal ion sin the oral environment because most 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 metals' characteristics; the second is environmental factors, such as mechanical stress, diet, time of the day, salivary flow rate, and health psychosomatic condition of the individual [13]. The present study results indicated an overall significant increase in salivary cobalt, zinc, and magnesium level of the orthodontic patient after fixed orthodontic appliance placement. The release of salivary cobalt was non-detectable at pretreatment, then increased one month after appliance placement which was 1.44 ppb, then decreased four months after appliance placement which was 0.05 ppb. The release of salivary magnesium was 4021. 16 ppb at pretreatment, then increased one month after appliance placement which was 10125.05 ppb, then decreased four-month after

appliance placement which was 224.27 ppb. The release of salivary zinc was 32.33 ppb at pretreatment, then increased one month after appliance placement which was 281. 11 ppb, then decreased at four-month after appliance placement which was 189.72 ppb.

Results of the present study indicated that the cobalt levels in saliva one month after fixed appliance placement (group II) were significantly higher than in pretreatment (group I). However, there was no statistically significant difference in cobalt levels in saliva between pretreatment (group I) and four months after fixed appliance placement (group III). These findings follow the study done by Jurela et al. [14]. They reported a non-statistically significant difference in cobalt level in saliva six months after fixed appliance placement compared with pretreatment levels. While dissimilar to the study reported by Rai et al. [15]. They found a statistically significant difference in cobalt level in saliva three months after fixed appliance placement compared with pretreatment level.

In the present study, magnesium level in saliva one month after fixed appliance placement (group II) was significantly higher than the pretreatment level (group I). Arash et al. [1] reported similar results to the present study regarding the statistically significant difference in magnesium levels in saliva between pretreatment and one month after fixed appliance placement. In contrast, Arash et al., in the same study, reported different results from the present study. They found a statistically significant difference in magnesium six months after fixed orthodontic appliances compared with pretreatment magnesium levels. Asin the present study, there was a non-statistically significant difference in magnesium level four months after fixed orthodontic appliances compared with the magnesium level pretreatment level of magnesium. In the present study level of zinc in saliva one month after fixed appliance placement (group II) was significantly higher than the pretreatment level (group I) and level four months after fixed appliance placement (group III). Similar results to the present study reported by Jurela et al. [14], they reported a statistically significant increase in zinc level in saliva six months after fixed orthodontic appliance placement compared with pretreatment level. The difference between the results of the 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.

5. Conclusion

Cobalt, magnesium, and zinc levels in saliva significantly increased after a fixed orthodontic appliance placement but gradually decreased. Also, maximum cobalt, magnesium, and zinc ions in saliva were found after one month of fixed orthodontic appliance placement.

5.1. Limitations

It was not feasible to achieve blinding of the investigator and participants. Short-term follow-up for 3 months during the alignment and leveling stage was conducted since only brackets, arch wires, and ligatures were used, excluding other methods, such as elastics, power chains, and coils. In future studies with a larger sample, types of drinks, food, oral hygiene, and other confounders are to be considered.

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