

Salivary Nickel and Chromium in Patients With Fixed Orthodontic Appliances

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Abstract: The purpose of this study was to determine the alterations in the chromium and nickel concentrations in the saliva of orthodontic patients treated with fixed orthodontic appliances. Forty-five orthodontic patients were included in this study. The first group consisted of 15 patients (7 female, 8 male) with fixed appliances placed in their upper and lower arches. The second group consisted of 15 patients (8 female, 7 male) with a fixed appliance placed only in the upper arch. The control group consisted of 15 patients (7 female, 8 male) who were not undergoing orthodontic treatment. Four samples of stimulated saliva were collected from each patient before insertion of the fixed appliance, 1 week after insertion of the appliance, 1 month after insertion of the appliance, and 2 months after insertion of the appliance. The same 4 samples of saliva were collected from each control patient at the same time intervals as for the fixed-appliance groups. The chemical analyses were done with an electrothermal atomic absorption spectrophotometer (Perkin Elmer 2380, Perkin Elmer Corp, Baden Seewerk, Germany). The Wilcoxon matched-pairs signed ranks test was used to test differences between samples before and after insertion of orthodontic appliances. A Kruskal Wallis 1-way analysis of variance was used to test differences in nickel and chromium concentration among the 3 test groups. It was observed that there was a large variation in the concentrations of both nickel and chromium in saliva. No significant differences were found between the no-appliance group and the samples obtained after insertion of the appliances. The results of the study suggest that fixed orthodontic appliances do not significantly affect nickel and chromium concentrations of saliva during the first 2 months of treatment. (*Angle Orthod* 2000;70:000–000.)

Key Words: Nickel; Chromium; Salivary concentration; Fixed orthodontic appliances

INTRODUCTION

A large variety of metallic alloys are routinely used in dentistry. Gold was used in orthodontics for fabrication of the accessories until the 1930s and 1940s. In 1929, stainless steel was used for the first time to replace gold. Orthodontic bands, brackets, and wires are universally made of austenitic stainless steel containing approximately 8–12% nickel and 17–22% chromium.^{1,2} These elements give stainless steel its ductility and corrosion resistance. Nickel-titanium alloys were introduced for use as orthodontic wires in the

1970s, and these alloys introduced another potential source of metallic corrosion products that could result in patient exposures.²

Less information exists on corrosion of orthodontic appliances in the oral cavity during treatment. Discoloration on the underlying tooth surface during orthodontic treatment has been regarded as the consequence of crevice corrosion of the bracket bases.^{3,4} Kratzstein et al⁵ observed signs of corrosion on many orthodontic appliances and on all appliances after 10 months.

The salivary nickel concentration has shown no consistent increase in patients with fixed orthodontic appliances, but rather an overall large variation.^{6–8} The amount of nickel and chromium released from fixed orthodontic appliances in vitro varies depending on the manipulation of the appliances and on different physical and chemical test conditions.^{1–10} Park and Shearer⁹ reported an average release of 40 µg nickel and 39 µg chromium per day from a simulated full-mouth fixed appliance. The release of nickel is not necessarily proportional to the alloy's nickel content.¹

Both nickel and chromium can cause hypersensitivity in some people. Nickel, in particular, is the most common contact allergen in women.¹¹ Concomitant increases in the

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prevalence of nickel hypersensitivity and the demand and availability of orthodontic treatment have created growing interest in the composition of alloys and the release of metals during treatment.

The aim of this study was to investigate the nickel and chromium concentrations in the saliva of orthodontic patients treated with fixed orthodontic appliances.

MATERIALS AND METHODS

The study used salivary samples collected from new patients starting orthodontic treatment. A total of 45 patients participated in the study. Fifteen patients (7 female, 8 male) with a mean age of 13.6 years ($SD \pm 1.2$ years) had upper and lower fixed appliances with nonextraction therapy. Fifteen patients (8 female, 7 male) with a mean age of 14.7 years ($SD \pm 0.8$ years) had only maxillary fixed appliances with nonextraction therapy. The remaining 15 patients (7 female, 8 male), with a mean age of 12.8 years ($SD \pm 2.1$ years), served as controls with no orthodontic appliances in place.

In the upper and lower fixed orthodontic appliance group, the patients had maxillary molar bands with edgewise triple buccal tubes (Ortho-cast, 724-006, Dentauro J. P. Winkelstroeter KG Turstrabe 37 D-75228 Ispringen, Germany) and second and first premolar, canine, and lateral and central incisor direct-bonded brackets (Roth .018' Ultratrim, 713-0075, 794-3116, 788-3016, and 785-3006; Dentauro J. P. Winkelstroeter KG Turstrabe 37 D-75228 Ispringen, Germany). In the mandible, these patients had mandibular first molar bands with edgewise double rectangular buccal tubes with vertical ball hook (Ortho-cast, 724-002, Dentauro) and first and second premolar, canine, and lateral and central incisor direct-bonded brackets (Roth .018' Ultratrim, 714-6215, 793-3248, 788-0055, and 788-0055; Dentauro).

In the upper-fixed-appliance-only group, the patients had the same maxillary attachments mentioned above. In both of the groups, there were no buttons either on the molar bands or on the other teeth. The arch wire was 016' nickel titanium (Rematitan, 766-040-maxillary, 766-240 mandibular; Dentauro), which was applied to the brackets with elastomeric units (Dentalastics, 774-002; Dentauro).

Sampling of saliva

Four samples of stimulated saliva were collected from each orthodontic patient at the following times: before insertion of the fixed appliance, 1 week after insertion of the appliance, 1 month after insertion of the appliance, and 2 months after insertion of the appliance. The same 4 samples of saliva were collected from each control patient at the same time intervals as for the fixed appliance groups.

Saliva collection

The patients initially rinsed their mouths thoroughly with a mouthful of distilled, deionized water. After mouth rinsing, the patient used a piece of paraffin (Parafilm M Laboratory film; American National Can, Chicago, Ill) as a chewing gum for stimulation of the salivary secretion. The patient collected approximately 10 mL of saliva into a polypropylene test tube. The samples were stored at -20°C before they were processed. The same person collected all the salivary samples from the subjects at the department of orthodontics.

Salivary preparation and analysis

Chromium and nickel concentrations of saliva are stable for 6 months when stored at -20°C . Extraction methods can be used for isolation and purification of elements from biological materials. The use of an atomic absorption spectrophotometer permits the analysis of metals in biological samples without any separation of the metal from its biological matrix. By using the spectrophotometric method, there is no necessity for extraction procedures to analyze the elements.¹² The only dilution of the samples was enough to eliminate the interference and effects of the biological matrix (protein, salts, and others). A volumetric flask was used to dilute each 0.5 mL of saliva samples to 10 mL. The samples were analyzed with an atomic absorption spectrophotometer (model 2380, Perkin Elmer), and the nickel and chromium concentrations present were calculated as micrograms per milliliter. The use of standard samples controlled the accuracy of the equipment. The error associated with this method of analysis was 1%.

Analysis of data and statistics

The Wilcoxon matched-pairs signed ranks test was used to test differences between samples before and after insertion of the orthodontic appliances. A Kruskal Wallis 1-way analysis of variance (ANOVA) was used to test differences in nickel and chromium concentrations among the 3 test groups.

RESULTS

The mean salivary nickel and chromium concentrations ($\mu\text{g/mL}$) of the upper and lower fixed appliance group, the upper fixed appliance-only group, and the control group after periods of 1 week, 1 month, and 2 months are shown in Table 1.

A large variation in the concentrations of both nickel and chromium was present in the saliva. The nickel concentration varied from 0.07 to 3.32 $\mu\text{g/mL}$, and the chromium concentration varied between 0.29 and 8.0 $\mu\text{g/mL}$. No significant differences were found between the no-appliance group and the fixed appliance groups tested by the Wilcox-

TABLE 1. Mean Salivary Nickel and Chromium Concentrations and Standard Deviations ($\mu\text{g/mL}$)

Time	Control		Upper Fixed Appliance Group		Upper-Lower Fixed Appliance Group	
	Ni	Cr	Ni	Cr	Ni	Cr
Before insertion	1.16 \pm 0.28	2.20 \pm 1.31	0.53 \pm 0.17	1.35 \pm 0.64	0.54 \pm 0.16	1.41 \pm 1.06
1 wk later	1.46 \pm 0.57	3.43 \pm 2.81	0.49 \pm 0.19	0.49 \pm 0.19	0.58 \pm 0.28	1.98 \pm 1.12
1 mo later	1.33 \pm 0.76	2.50 \pm 2.04	0.51 \pm 0.20	0.94 \pm 0.59	0.67 \pm 0.33	1.27 \pm 0.70
2 mo later	1.41 \pm 0.96	3.18 \pm 1.82	0.53 \pm 0.34	1.07 \pm 0.43	0.64 \pm 0.25	1.42 \pm 1.17

TABLE 2. The Statistical Differences of Salivary Nickel Concentrations in Control, Upper Fixed Appliance, and Upper and Lower Fixed Appliance Groups

Nickel	Control Group	Upper Fixed Appliance Group	Upper and Lower Fixed Appliance Group
	<i>P</i>	<i>P</i>	<i>P</i>
Before insertion/1 wk later	.594	.916	.350
Before insertion/1 mo later	.477	.977	.783
Before insertion/2 mo later	.477	.629	.328
1 wk later/1 mo later	.722	.851	.077
1 wk later/2 mo later	.929	.820	.754
1 mo later/2 mo later	.790	.910	.350

TABLE 3. The Statistical Differences of Salivary Chromium Concentrations in Control, Upper Fixed Appliance, and Upper and Lower Fixed Appliance Groups

Chromium	Control Group	Upper Fixed Appliance Group	Upper and Lower Fixed Appliance Group
	<i>P</i>	<i>P</i>	<i>P</i>
Before insertion/1 wk later	.929	.211	.594
Before insertion/1 mo later	.328	.094	.286
Before insertion/2 mo later	.286	.256	.859
1 wk later/1 mo later	.504	.594	.136
1 wk later/2 mo later	.813	.733	.937
1 mo later/2 mo later	.350	.570	.099

on test (Tables 2 and 3). The Kruskal Wallis 1-way ANOVA showed that the differences between the mean concentrations of nickel and chromium in the different appliance groups were not statistically significant ($P > .05$).

DISCUSSION

The results of the current study show that there were no statistical differences in salivary nickel and chromium concentrations before and 2 months after insertion of different fixed orthodontic appliances. In this study, the nickel and chromium concentrations in the saliva showed a large variation. Large variations have also been found in previous reports of metal concentrations in saliva.⁷⁻¹⁰ The findings of the current study are in accordance with the study by Kerosuo et al,⁸ who did not find any significant increase in nickel and chromium concentration in saliva of orthodontic

patients after insertion of different fixed appliances. The present study is also in accordance with the study by Gjerdet et al,⁷ who did not find any differences in nickel amounts in saliva before and 3 weeks after insertion of fixed appliances. The continuous flow of saliva in the mouth and short sampling period may not give time enough for a detectable dissolution of nickel and chromium to separate from the fixed appliances.

Gjerdet et al⁷ found an increase in salivary nickel concentration in saliva samples taken immediately after placement of orthodontic appliances in a group of 6 cases. In the current study, the first salivary samples with fixed orthodontic appliances were collected 1 week after placement of appliances. Conceivably, the differences between these 2 studies can be related to this time factor.

Park and Shearer⁹ reported a release of 40 μg nickel and 36 μg chromium per day from a simulated full-mouth orthodontic appliance. The simulated orthodontic appliance was constructed for half of a mandibular arch and consisted of first and second molar bands, first and second premolar bands, and canine, lateral incisor, and central incisor brackets that were immersed into a 0.05% saline solution. In the current study, the patients had first molar bands and first and second premolar, canine, lateral, and central incisor direct bonding brackets. We cannot compare the in vitro concentrations of nickel and chromium to the in vivo concentrations. In the oral cavity, such factors as temperature, quantity and quality of saliva, plaque, physical and chemical properties of food and liquids, and oral health conditions may influence the results.

The composition of the saliva may be affected by many physiologic variables, such as time of the day, health conditions, diet,¹³ and salivary flow rate.¹⁴ Oral daily intake of nickel by food is estimated¹⁵ to be between 300 and 600 μg . The major dietary sources for these metals are vegetables, grains, and cereals.² Analysis of amounts of metals from in vivo saliva, where concentrations are more diluted and affected by the salivary flow rate and diet, seem to be insufficient for differentiating appliance-related, apparently small changes from the overall high normal variation of nickel in saliva. The procedure of sampling, preparation, and analysis of saliva samples on low-level concentrations of metals involves a risk of contamination during the procedure. In the current study, to eliminate the risk of contamination, maximum care was taken, and the sterile par-

affin wax used as a chewing gum for stimulation of the salivary secretion did not contain any nickel.¹⁶ Although parotid and submandibular saliva can be collected separately, paraffin-stimulated whole saliva determination is usually adequate as a routine procedure.¹⁷

The concentrations of salivary nickel and chromium, with and without appliances, were somewhat higher in this study compared with earlier reports of these metals in saliva.^{6,7} The design of some of the studies is similar, but they used unstimulated saliva samples.

In the in vitro studies,^{3,7,8} soluble nickel concentrations exceeded those of chromium. In our study, there was not a distinct difference between salivary nickel and salivary chromium concentrations. Nickel and chromium concentrations were approximately equal. This difference can be explained by the methodologies of in vivo and in vitro experiments. There are no distinct data about the binding of nickel to protein.¹⁸ In contrast to the in vitro study,¹⁰ no statistically significant differences in the saliva concentration of nickel and chromium between patients with different appliances were seen.

The nickel and chromium concentrations in the present study are higher than those reported by Kerosuo et al.⁸ The difference can be explained by dietary habits. The people who live in that area consume more grains and cereals. The salivary nickel and chromium concentration between these 2 studies might be explained by diet, as the major dietary sources for these metals are vegetables, grains, and cereals.²

Nickel and chromium are 2 metals often used in the construction of various parts of orthodontic appliances. The potential health effects from exposure to nickel and chromium and their compounds have been scrutinized for more than 100 years. It has been established that these metals could cause hypersensitivity, dermatitis, and asthma, so there is the possibility that nickel and chromium released from stainless steel orthodontic bands, brackets, and wires might elicit an allergic reaction.¹⁹⁻²²

The results of the study suggest that fixed orthodontic appliances do not significantly affect the salivary concentrations of nickel and chromium during the first 2 months of treatment.

CONCLUSION

Fixed orthodontic appliances do not seem to significantly affect the salivary concentrations of nickel and chromium during the first 2 months of treatment. Although the orthodontic appliances did not have any effect on the general level of nickel concentration in saliva, it cannot be excluded that minor amounts of nickel dissolved from appliances could be important in cases of hypersensitivity to nickel.

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