Research Article

Estimation of nickel and chromium in two mediums of artificial saliva having fixed orthodontic appliance

Sunita Sugumaran, Saravana Pandian*

ABSTRACT

Aim: The aim of this study was to estimate the amount of nickel and chromium released from fixed orthodontic appliance in two different artificial saliva media (normal pH salivary media and oxidizing salivary media) and to estimate the weight loss of the fixed appliance. **Materials and Methods:** This *in vitro* study was performed using a classic batch procedure by immersion of the samples in two artificial salivary media: (a) In normal salivary media and (b) in oxidizing salivary media. A classic bath consists of (a) 4 molar bands, (b) 20 brackets, and (c) 2, 0.016 NiTi upper and lower archwires. Two beakers were taken with 200 ml of artificial saliva, respectively. In 1 beaker, 2 ml of 5% hydrogen peroxide was added to achieve oxidizing media. Dry weight of the batch was tested at the start of the treatment. Nickel and chromium content was tested in the artificial saliva before the start of the treatment using atomic absorption spectrophotometer. The batches were then immersed into the saliva in the beakers. Applying Arrhenius equation, the salivary media were heated up to 60°C so as to accelerate the rate of reaction and was maintained for 8 h. At the end of the treatment, nickel and chromium were estimated using an atomic absorption spectrophotometer. The batches were dried, and the dry weight was again checked to estimate the weight loss. **Results:** In this study, it is noticed that nickel is not released in detectable amount. However, chromium release is noticed in both the salivary mediums after heat treatment and is high in the oxidizing media as compared to the normal media, indicating that an oxidizing media have an effect and favor the release of chromium. Chromium is found to be slightly more than the daily dietary allowance but is within the therapeutic level.

KEY WORDS: Arrhenius equation, Fixed orthodontic treatment, Salivary Ni-Chr

INTRODUCTION

Different varieties of metal alloys are used regularly 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 1st 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.[1-3] These elements give stainless steel, its ductility, and corrosion resistance. Nickel–titanium alloys were introduced for use as orthodontic wires in the 1970s, by William Bheuler in naval ordinance laboratory. These alloys contained 55% of nickel and 45% of titanium and possessed a potential source of corrosion.[2] Corrosion leads to leaching of these metal ions in the saliva increasing the patient. The amount of metal release depends on the manipulation of the appliance, physical, and environmental conditions.[1,2,4-10] In the past few years, there is an increased awareness regarding biocompatibility of dental materials. Oral environment causes biodegradation of metals. Of importance is the release of nickel and chromium as these both are known to cause an allergic reaction and is notorious for its mutagenic effect.[11] Nickel and chromium both cause allergic reaction, and nickel, in particular, is known to cause contact dermatitis.[12]

This study is carried out to estimate the amount of nickel and chromium released from fixed orthodontic appliance in two different artificial saliva media (normal pH salivary media and oxidizing salivary media) and to estimate the weight loss of the fixed appliance.

Access this article online

Website: jprsolutions.info	ISSN: 0975-7619

MATERIALS AND METHODS

This *in vitro* study was performed using a classic batch procedure by two samples of artificial salivary media

Department of Orthodontics, Saveetha Dental College, Saveetha University, Chennai, Tamil Nadu, India

***Corresponding author:** Saravana Pandian, Department of Orthodontics, Saveetha Dental College, Saveetha University, Chennai - 600 077, India. Phone: +91-9003101627. E-mail: sporthoresearch@gmail.com

Received on: 12-08-2018; Revised on: 19-09-2018; Accepted on: 22-10-2018

which were prepared according to Macknight-Hank and Whitford (1992):
a) Normal salivary media
b) Oxidizing salivary media.

200 ml of artificial saliva was taken in two beakers. In one of the beakers, 2 ml of 5% hydrogen peroxide was added to achieve an oxidizing medium, so as to increase the pH of the solution to around 10.

A classic batch consists of:
a) 4 molar bands
b) 20 brackets
c) 2, 0.016 NiTi upper and lower archwires.

Dry Weight of the Batch was Tested at the Start of the Treatment

Nickel and chromium content was tested in the artificial saliva before the start of the treatment using atomic absorption spectrophotometer. This technique uses wavelengths of light specifically absorbed by an element. Standard calibration curves are made. 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. Using the spectrophotometric method, there is no necessity for extraction procedures to analyze the elements.[13]

The Batches were then Immersed into the Saliva in the Beakers

Applying Arrhenius equation [Figure 1], the salivary media were heated up to 60°C so as to accelerate the rate of reaction and were maintained for 8 h.[14]

At the end of the treatment, nickel and chromium were estimated using an atomic absorption spectrophotometer.

The batches were dried, and the dry weight was again checked to estimate the weight loss.

RESULTS

According to Tables 1-3, there is no evidence of nickel in both the mediums before and after treatment.

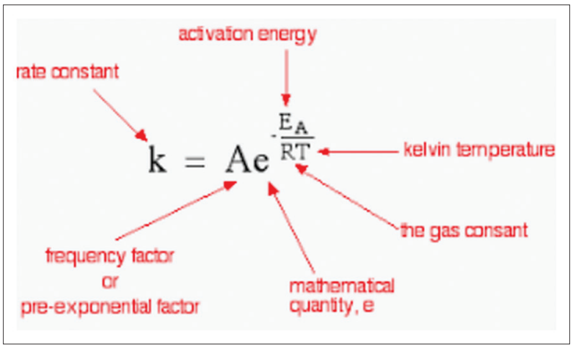

Figure 1: Arrhenius equation

Table 1: Normal salivary medium

Weight loss	0.04%	0.04%
Heavy metals	Before T/T	After T/T
Nickel	Not detected	Not detected
Chromium	Not detected	Not detected

Table 2: Oxidizing salivary medium

Weight loss	0.16%	0.16%
Heavy metal	Before T/T	After T/T
Nickel	Not detected	Not detected
Chromium	Not detected	3 ppm

Table 3: Calculation

Parameters		Oxidized	Normal
W	Mg	1.32512	0.33128
D	g/cm^3	8	8
A	cm^2	11.1768	11.1768
T	Hours	10	10
mmpy (Weight loss)	60c	0.129823062	0.03245577
mmpy	37c	0.032455766	0.00811394
Cr/yr	G	0.05223623	0.01305906
Cr/day	µg	47.70432	11.92608

Initial dry weight of the batch: 0.8282, Corrosion rate=87.6*W/DAT, W: Weight loss in mg, D: Metal density in g/cm^3, A: Area in cm^2, T: Time of exposure in hours

However, there is 3 ppm of chromium released after heat treatment in an oxidizing medium. Applying Arrhenius equation, the amount of chromium released per day is 11.92608 mg, and since a standard fixed orthodontics treatment goes up to 1.5–3 years, at the end of 3 years, the amount of chromium release can be expected to be about 0.01305906 gm.

DISCUSSION

The result of the current study shows that there is no statistical increase in the amount of Ni released in both the salivary medium; however, there is an increase in the amount of chromium in the oxidizing medium and it lies within the therapeutic limit.

Most orthodontic appliances are made of stainless steel and NiTi alloys which can release metal ions into the oral cavity.[15] The corrosion of metal and release of ions such as Ni has an additive rather than a linear relationship with time.[11] Both nickel and chromium are known to cause allergic reactions called contact dermatitis and belong to Type IV hypersensitivity reaction. For this form of allergy, the allergen or hapten is a substance with a low allergenic power.[16] Nickel and chromium are trace minerals and play an important part in the overall health. The average dietary intake of nickel is 200–300 µg/day. Nickel aids in iron absorption, as well as adrenaline, glucose metabolism, improving bone strength. and production of red blood cells. The primary route of eliminating nickel is through the urine. The dietary intake of chromium is 50–200 µg/day. The capacity of humans to absorb chromium is greatly influenced by the oxidation state of the chromium ion. Chromium regulates the functioning of insulin hormone and also facilitates the processing of carbohydrates and fats in the body. Excretion of absorbed chromium occurs mainly through the urine.

In higher doses, both Ni and Cr have been found to be harmful. Nickel has been systematically studied for detrimental effects at cell, tissue, organ, and organism levels. In higher doses, Ni can be an allergen or carcinogenic and act mutating substance by causing an alteration in DNA. Higher doses of chromium are also capable of inducing side effects which may include insomnia or irregular sleeping, headaches, vomiting, diarrhea, and irritability.[9] The skin reaction can occur at the site of contact or sometimes spread beyond to the rest of the body. Cutaneous exposure can cause localized erythematous, pruritic, vesicular, and scaly patches. Ingestion of nickel may cause a systemic reaction that will affect a larger skin surface. Examples of systemic reactions can include hand dermatitis, baboon syndrome, or generalized eczematous reactions.[17] This study is an *in vitro* study, and we cannot compare the *in vitro* concentrations of nickel and chromium to the *in vivo* concentrations. In the oral cavity, factors such as temperature, quantity, and quality of saliva, plaque, physical and chemical properties of food and liquids, and oral health conditions may influence the results. pH plays an important role in influencing the release of the metal ions. pH becomes acidic during consumption of acidic food, citrus juices, etc. On the other hand, it becomes basic during brushing. In this study, the saliva is stagnant, but in oral cavity, there is a constant flow of saliva and the influence of the pH is not for a longer period of time.[4,18] Chromium is seen to be released in basic pH. Even with Cr ions in saliva, the levels were below the toxic doses recommended by the WHO and will not cause adverse reactions in a cell, tissue, and organ level.

However, in conditions where the patient is allergic to Ni or Cr, such patients may show mild signs and symptoms of allergy. Such patients can be treated with alternative materials such as ceramic, polycarbonates, metal coated with epoxy resins, or components fabricated with other metals such as titanium, vanadium, Co-Cr, and aluminum.

In vivo test should follow the *in vitro* tests. Research should be carried for a longer time to study the effect of corrosion process and mechanical phenomenon such as wear and fatigue on the release of Ni and Cr in the oral cavity.

CONCLUSION

In our study, it is noticed that there is nickel which is not released in detectable amount. However, chromium release is noticed in both the salivary mediums after heat treatment, and is high in the oxidizing media as compared to the normal media, indicating that an oxidizing media have an effect and favor release of chromium.

Chromium is found to be slightly more than the daily dietary allowance but is well within the therapeutic levels.

REFERENCES

1. Grimsdottir MR, Gjerdet NR, Hensten-Pettersen A. Composition and *in vitro* corrosion of orthodontic appliances. Am J Orthod Dentofacial Orthop 1992;101:525-32.
2. Barrett RD, Bishara SE, Quinn JK. Biodegradation of orthodontic appliances. Part I. Biodegradation of nickel and chromium *in vitro*. Am J Orthod Dentofacial Orthop 1993;103:8-14.
3. Matos de Souza R, Macedo de Menezes L. Nickel, chromium and iron levels in the saliva of patients with simulated fixed orthodontic appliances. Angle Orthod 2008;78:345-50.
4. Maijer R, Smith DC. Corrosion of orthodontic bracket bases. Am J Orthod 1982;81:43-8.
5. Gwinnett AJ. Corrosion of resin-bonded orthodontic brackets. Am J Orthod 1982;81:441-6.
6. Guivarch C, Hallegatte S. 2C or Not 2C? SSRN Electron J 2012;23:179-92.
7. Koppenburg P, Bacher M, Geis-Gerstorfer J, Sauer K, Kratzenstein B, Weber H. *In-vivo* corrosion studies of orthodontic appliances. Dtsch Zahnarztl Z 1988;49:62-9.
8. Gjerdet NR, Erichsen ES, Remlo HE, Evjen G. Nickel and iron in saliva of patients with fixed orthodontic appliances. Acta Odontol Scand 1991;49:73-8.
9. Kerosuo H, Moe G, Hensten-Pettersen A. Salivary nickel and chromium in subjects with different types of fixed orthodontic appliances. Am J Orthod Dentofacial Orthop 1997;111:595-8.
10. Park HY, Shearer TR. *In vitro* release of nickel and chromium from simulated orthodontic appliances. Am J Orthod 1983;84:156-9.
11. Eliades T, Bourauel C. Intraoral aging of orthodontic materials: The picture we miss and its clinical relevance. Am J Orthod Dentofacial Orthop 2005;127:403-12.
12. Root R. Elements of Human Physiology. 2nd ed. Lucas MS, editor. Philadelphia, PA: Lea and Febiger; 1950. p. 132.
13. Laidler K. The development of the Arrhenius equation. J Chem Educ 1984;61:494.
14. Bass JK, Fine H, Cisneros GJ. Nickel hypersensitivity in the orthodontic patient. Am J Orthod Dentofacial Orthop 1993;103:280-5.
15. Analytical Chemistry. Vol. 22. New York: Masthead; 1950. p. 3A.
16. Maijer R, Smith DC. Biodegradation of the orthodontic bracket system. Am J Orthod Dentofacial Orthop 1986;90:195-8.

Source of support: Nil; Conflict of interest: None Declared