***ISSN:* 1812–1217**

Evaluation of Nickel Ion Release from Orthodontic Wires in Different Types of Artificial Saliva

Amer. A. Taqa
BSc. MSc. PhD (Prof)

Department of Dental Basic Science
College of Dentistry, University of Mosul

Wafaa Gh. Fathi
BDS., M.Sc. (Asst. Lec.)

Depart. of Pedod, Orthod and Preve Dentistry
College of Dentistry, University of Mosul

Ruba J. Mohammed
BDS, MSc, (Asst. Lec.)

Department of oral and maxillofacial surgery
College of Dentistry, University of Mosul

الخلاصة

الأهداف:تهدف هذه الدراسة إلى قياس كمية أيونات النيكل المزاحة من اسلاك الفولاذ المقاوم للصدأ لقوس تقويم الأسنان في لعاب اصطناعية مختلفة و في فترات زمنية مختلفة. **المواد وطرائق العمل** : شملت هذه الدراسة ست انواع تجارية مختلفة لأسلاك الفولاذ المقاوم للصدأ التقويمية بأقطار مختلفة تم غمرها في محلول الماء غير المتأين و ثلاث انواع لعاب اصطناعي مختلف وفترات الغمر تراوحت (7، 14و 30يوما) و استخدام فرن الجرافيت (مطياف الامتصاص الذري ((AAS) لتحديد كمية أيونات النيكل المتحررة . **النتائج**: أظهر التحليل الإحصائي أن هناك أهمية كبيرة في تحرر أيون النيكل لجميع أنواع الأسلاك ما عدا سلك 4 و 5 التي تعطي قيمة غير معنوية 2.45 و 1.37 على التوالي، و ان الفترة الزمنية للغمر ليس لها فرق معنوي لجميع أنواع الأسلاك. **الاستنتاجات** : نوع السلك ومساحته السطحية التي تلامس السوائل اثناء الغمر تؤثر على كمية ايونات النيكل المزاحة وكذلك تركيب السلك اثر في كمية اطلاق الايون .

ABSTRACT

Aims: To evaluate the amount of nickel ion release from stainless steel orthodontic wires in different artificial saliva and in different time periods. **Materials and Methods**: This study included six different commercial stainless steel orthodontic wires with different diameters. They were immersed in deionized water (control) and three different artificial saliva, the immersion periods included 7, 14, and 30 days. A graphite-furnace atomic absorption spectrometer (AAS) was used to determine the amount of nickel ions release. **Results**: The statistical analysis showed that there is a highly significance in the release of nickel ions for all types of wire except wires 0.18, and 0.16 x 0.22 which gave non-significant 2.45 and 1.37 respectively, and the time period of immersion had no significant effect in all types of wire. **Conclusions**: The release of nickel ions was influenced by the types of wire and the surface areas that in contact with immersion in solution, in addition to the composition of the orthodontic wires, but this were not proportional to the content of metal in the wire.
Key words: Nickel ion, arch wires, fixed orthodontic appliance.

Taqa AA, Fathi WG, Mohammed RJ, Evaluation of Nickel Ion Release from Orthodontic Wires in Different Types of Artificial Saliva. ". *Al–Rafidain Dent J*. 2014; 14(2):182-188.
Received: 22/10/2012***Sent to Referees:*** 23/10/2012***Accepted for Publication:*** 25/2/2013

INTRODUCTION

Dentistry has the main purpose for keeping or improving the patient's quality of life by preventing diseases, relieving pain and improving the masticatory efficacy, phonetics and/ or esthetics. Most of these objectives require replacement or alteration of the existing dental structures, as well as changes in the tooth positioning, developing and selecting biocompatible materials have been one of the major challenges in dentistry.(1) Metals, ceramics, polymers and composites are the four groups of materials that are currently employed.(2)

Little scientific information on these materials was available until the middle of the last century. Toxic, inflammatory, allergic or mutagenic reactions are the possible biological response to these materials.(3-6) Toxicity is one of the main parameters of evaluating the biological response and the potential damage to cells and tissues related to the use of such materials.(7-9)

There has been concern about hypersensitivity reactions of nickel allergic subjects in association with metallic orthodontic appliances. Adverse responses have been reported occasionally[10,11] .In general, nickel sensitivepatients have not been found to be at any greater risk of developing discomfort in the oral cavity during orthodontic treatment compared with no sensitive patients. [12] Sensitizing patients to nickel through routine orthodontic treatment with fixed appliances have also been a concern, although evidence is scarce. [13, 14]

Nickel is a strong sensitizer and one of the most common causes of contact allergies.[15] In vitro, release of nickel from orthodontic appliances has been noted using microscopic analysis of corrosion, as well as chemical analyses of orthodontic components when exposed in an artificial oral environment.[16-19] When incubated in artificial saliva, orthodontic appliances of various types release 22-4μg nickel per day, compared with the estimated dietary intake of between 100 and 800μg per day (international programmer on chemical Safety (IPCS) -1991).[20] Release of nickel is reported to vary with composition and manufacturing of the appliance components (18) and between arch wires alloys and mechanical straining, but not actual nickel contents. [21-22]

MATERIALS AND METHODS

This study used simulated fixed orthodontic appliances, each of which represented half of the upper and lower archwires. Six different commercial stainless steel orthodontic wires with different diameters were used in this study. The materials used were made by International Orthodontic Service. USA (IOS) size 0.018 lower, International Orthodontic Service USA (IOS) size (0.016 x 0.022) upper, Ortho matrix USA (Spain division) size (0.016 x 0.022) lower, Ortho matrix USA (Spain division) size 0.018 lower, Hallimex Dental Germany size (0.016 x 0.022) upper and Midwest orthodontics Ltd. Size (0.016 x 0.016) Columbus lower.

Three samples of each type of stainless steel wires were prepared to immerse in de-ionized water and artificial saliva. All products were sullied as a straight length with cross sections with distances as the following ((0.018, (0.016 x 0.022), (0.016 x 0.022), 0.018, (0.016 x 0.022) and (0.016 x 0.016)) (16.5, 17.3, 16.5, 19.2, 16.8, and 16.1cm) respectively. These distances gave the same surface area for all wires in the different artificial saliva. To simulate changing conditions in the oral cavity, different artificial saliva were used.

Immersion Tests:

Within each group, specimens kept in three different types of artificial saliva as shown Table (1), three specimens from each type of stainless steel wires kept in type of artificial saliva medium, and the last three specimens kept in deionized water as control group 37°C(23). The test wire with an exposure length of 15 cm was dipped in a glass tube (15 ml) and maintained at 37° C. The immersion periods included 7, 14, and 30 days.

Table (1):Chemical composition of three different artificial saliva mediums.

1- Artificial saliva composition (12) type (1)	
Component's	**Concentration (glL)**
NaCl	0.40
KCl	0.40
$CaCl_2$. $2H_2O$	0.795
NaH_2 PO_4.2 H_2O	0.780
Na_2S_9 H_2O	0.005
CO $(NH_2)_2$ (Urea)	1.0
Distilled water	1000ml
2- Artificial saliva composition (11) type (2)	
Components	**Concentration (mg/ml)**
NaCl	125.6
KCl	963.9
KSCN	189.2
KH_2 PO_4	654.5
Ureia	200.0
Na_2 SO_4, 10 H_2O	763.2
NH_4Cl	178.0
$CaCl_2$, $2H_2O$	227.8
$NaHCO_3$	630.8
3- Artificial saliva composition (1) type (3)	
Component	**Concentration (g/l)**
Zanthangum	0.92
Potassium chloride	1.2
Sodium chloride	0.85
Magnesium chloride	0.05
Calcium chloride Di-Potassium	0.13
Sodium di-hydrogen phosphate	0.13
Methyl-polyhydroxy Benzoate	0.35

Atomic Absorption Spectrometer Analysis:

A graphite-furnace atomic absorption spectrometer (AAS) (Model 302, Germany) was used to determine the amount of nickel ions released after different immersion periods in three types of artificial saliva and de-ionized water. The measurements were carried at Biology Department, College of Science / Mosul University.

Statistical Analyses:

For statistical analysis was done using SPSS program version 11.5, One Way Analysis of Variances (ANOVA) and Duncan's Multiple Range Test were used to test the effects of two independent variables (types of wires and solutions) and one dependent (time/length of immersion) variable.

RESULTS

Results of the analysis of concentration of released nickel ion were shown in Figure (1).

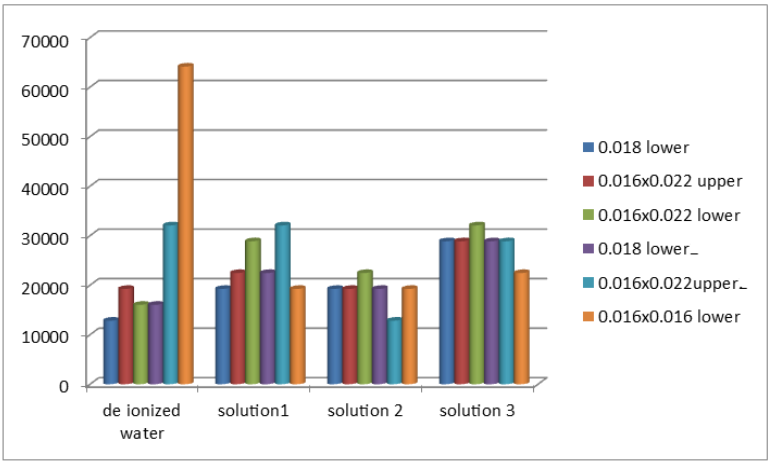

Figure (1): The quantity of released metal ion during one month and the totalquantity of metal ion released in the experiment solutions and control.

The graph displayed the quantity of released metal ion during one month and the total quantity of metal ion released in the experiment solutions and control. The amount of nickel ions from six different wires one immersiontime with various solutions.

The accumulated amount of nickel ion increased with longer immersion period for all wires tested a slower increasing trend of metal ion with longer immersion period was observed in deionized solution. Regardless of wire 6 immersions exhibited the highest release amount of nickel ions.

The statistical analysis ANOVA (Table 2) showed that there is a highly significance in the release of nickel ion in all types ofwire except wire 4 and 5 which gave non-significant difference 2.45 and 1.37 respectively.

Table (2): Analysis of Variance (ANOVA) of the nickel ion release from different shapes of stainless steel wires in different solutions

wires		Sum of squares	df	Mean Square	F-value	*p*-value
0.018 lower	Between Groups Within Groups Total	1.357 E-5 0.617 E-5 1.974 E-5	4 10 14	3.393 E-6 0.617 E-6	5.500	0.013*
0.016x0.022 upper	Between Groups Within Groups Total	1.394 E-5 0.432 E-5 1.826 E-5	4 10 14	3.485 E-6 0.432 E-6	8.071	0.004*
0.016x0.022 lower	Between Groups Within Groups Total	1.937 E-5 1.110 E-5 3.047 E-5	4 10 14	4.843 E-6 1.110 E-6	4.361	0.027*
0.018 lower	Between Groups Within Groups Total	1.394 E-5 1.419 E-5 2.813 E-5	4 10 14	3.485 E-6 1.419 E-6	2.457	0.114
0.016x0.022 upper	Between Groups Within Groups Total	2.443 E-5 4.442 E-5 6.885 E-5	4 10 14	6.107 E-6 4.442 E-6	1.375	0.310
0.016x0.016 lower	Between Groups Within Groups Total	1.135 E-5 5.679 E-5 1.814 E-5	4 10 14	2.838 E-6 0.679 E-6	4.182	0.030*

* Means statistically significant at ($P > 0.05$).

Tables (3, 4) showed the effect of different solutions on the release of nickel ions after one month immersion. The results revealed that all solutions have the same effect with the different types of wire.

Table (3): Duncan Test Analysis of the nickel ion release from different shapes of stainless steel wire in different solutions.

Solutions	Sum of squares	df	Mean Square	F-value	*p*-value
Deionized water Between Groups Within Groups Total	0.000 0.000 0.000	5 12 17	0.000 0.000		
Distilled water Between Groups Within Groups Total	1.090E-5 2.344E-5 3.434E-5	5 12 17	2.180E-6 1.954E-6	1.116	0.402
Solution 1 Between Groups Within Groups Total	0.416E-5 2.221E-5 2.637E-5	5 12 17	0.833E-6 1.851E-6	0.450	0.806
Solution 2 Between Groups Within Groups Total	0.149E-5 0.864E-5 1.013E-5	5 12 17	0.298E-6 0.720E-6	0.414	0.830
Solution 3 Between Groups Within Groups Total	0.149E-5 3.270E-5 3.419E-5	5 12 17	0.298E-6 2.725E-6	0.109	0.988

Table (4): Duncan test Analysis of the nickel ion release from different shapes of stainless steel wire in different times.

Time	N	Mean	Std. D
7 days	30	2.02020	1.896435
14 days	30	1.89193	1.143382
30 days	30	1.37887	1.176398
Total	90	1.76367	1.458232

Table (4) indicated the time period for immersion had no significant difference for all types of wires (F=1.648) as shown in Table (5).

Table (5): Analysis of Variance (ANOVA) for the period time for immersion had no significantdifference for all types of wires.

Period Time		Sum of squares	df	Mean Square	F-value	*p*-value
7 days	Between Groups	6.910E-6	2	3.455E-6		
14 days	Within Groups	182.343E-6	87	2.096E-6	1.648	0.198
30 days	Total	189.253E-6	89			

DISCUSSION

The release of nickel ions from orthodontic stainless steel wires is a phenomenon that cannot be avoided; it is difficult to find a material that will be fully stable within an organism and will show no signs of biodegradation. A growing number of recent studies have investigated the problem of biocompatibility with the goals of (1) determining the upper limit of biological tolerance and (2) finding means through which the release of ions will be kept within these limits. This study identified the effects of changes in solution and of the wire material on the release of nickel metal ions. However, the absorption of released metal ions and their effects on oral tissues remain to be examined in future in vivo studies.

This study emphasizes the importance of several factors that can influence the release of nickel ions from fixed orthodontic appliances, namely, the type of alloy, the effect of the solution, and the length of immersion and of course the appliance consisted of the stainless steel wires. This study demonstrates that the release of nickel ion depended only on the type of wire and the surface area of wire that will contact with immersion solution.

Results from immersion tests revealed that the highest amount of nickel ions released in solution [3] immersions for all types of wires. If a full-mouth appliance is considered, the total length of nickel ions orthodontic wire can be estimated to be around 15 cm (including upper and lower arch). Although, the difference in chemical composition of different solutions, but after one month of immersion they gave non-significant difference as indicated in Tables (3, 4), although these results disagree with previous study [23] which assumed that the release of ion on the length of exposure, but these results agree with other studies (18, 24), which have suggested that the quantity of released metal ions is depended on the content of metal (chemical content) in the wire alloy. Although the quantities of released metal ions measured in this and similar studies cannot be directly applied to in vivo conditions, they are useful for relative comparisons and for determination of the effect of each individual variable (e.g., artificial saliva) on ion release without the influence of external factors.

CONCLUSIONS

•The difference in chemical composition of artificial saliva has no effect on the amount of nickel ion release.

•All solutions have similar effect on the nickel ion release although the different in chemical composition of these solutions.

•The shapes of wire and surface area that contact with immersion in solution have influenced amount of ion release.

•The time of the exposure of wires to the solution after one month has no significant effect on the ion release.

•Release of metal ions was influenced by composition of the orthodontic wire, but this was not proportional to the content of metal in the wire.

REFERENCES

1. Jorge JH, Giampaolo ET, Vergani CE, Pavarina AC, Machado AL, Carlos IZ. Effect of microwave postpolymerization treatment and of storage time in water on the cytotoxicity of denture base and reline acrylic resins. *Quintessence Int.* 2009; 40 (10) :e93-100.
2. MriasLS,SerraGS,MullerCA,PalermoE FA,AndradeLR,Meyers MA et al. .In vivo metal ion release from Ti-6 Al-4V orthodonticminiiplants.*RevistaMatêria.* 2007; 12:290-297.
3. Gioka C, Bouranel C, HiskiaA, KletsasD, Eliades T, EliadesG..Light – cured or chemicalycured orthodontic adhesive resins? Aselection based on the degree ofcure,monomerleaching, and cytotoxicity. *Am J. Orthod Dentofacial Orthop*; 2005; 127: 413-419; quiz 516.
4. Hanson M, Lobner D. In vitro neuronal cytotoxicity of latex and nonlatex orthodontic elastics. *Am J Orthod Dentofacial Orthop* 2004; 126: 65-70?
5. Howdeshell KL, Peterman PH, Judy BM, Taylor JA, Orazio CE, Ruhlen RL, et al. Bisphenol A is released from used polycarbonate animal cages into water at room temperature. Environ Health Perspect; 2003; 111(1):180-7.
6. Siqueira Goncalves T, Minghelli Schmitt V, Thomas M, Lopes de Souza MA, Macedo de Menezes L. Cytotoxicity of two autopolymerized acrylic resins used in orthodontics. *Angle Orthod* 2008; 78: 926-30.
7. Kao CT, Ding SJ, Min Y, Hsu TC, Chou MY, Huang TH. The cytotoxicity of orthodontic metal bracket immersion media. *Eur J Orthod* 2007; 29: 198-203.
8. MatheusMeloPithon, RogérioLacerda dos Santos, Fernanda Otaviano Martins, Antônio Carlos de Oliveira Ruellas, Lincoln IssamuNojima, MatildeGonçalvesNojima, Maria Teresa VillelaRomanos. Cytotoxicity of polycarbonate orthodontic brackets. *Braz J Oral Sci*. 2009; 8(2): 84-7.

9. Moffa JP, Beck WD, Hoke AW. Allergic response to nickel containing dental alloys. *J. Dent. Res*. 1977; 56.
10. Dunlap CL, Vincent SK, Barker BF. Allergic reaction to orthodontic wire: report of a case. *J. Am. Dent. Ass*. 1989; 118: 449-450.
11. Staekjaer L, Mennê T. nicke allergy and orthodontic treatmen. *Eur. J Orthod.* 1990; 12: 284-289.
12. Bass JK, Fine HF, Cisneros GJ. Nickel hypersensitivity in the orthodontic patient. *Am. J. Orthod. Dentofac.Orthop.*1993; 103: 280-285.
13. Vreeburg K J J, De Groot K, von Blomberg B M E, Scheper R J Induction of immunological tolerance by oral administration of nickel and chromium. *J Dental Research* 1984; 63: 124 – 128.
14. Nielsen N H, Menné T Nickel sensitization and ear piercing in an unselected Danish population. Glostrup allergy study. Contact Dermatitis 1993; 29: 16 – 21.
15. Park H Y, Shearer T R In vitro release of nickel and chromium from simulated orthodontic appliances. *Am J Orthod* 1983; 84: 156 – 159?
16. Kocadereli L, Atac P A, Kale P S, Özer D Salivary nickel and chromium in patients with fi xed orthodontic appliances. *Angle Orthod* 2000; 70: 431 – 434.
17. Grimsdottir MR, Gjerdet NR, Hensten-Pettersen A. Composition and in vitro corrosion of orthodontic appliances. *Am J Ortho Dentofac Orthop*. 1992; 101: 525-32.
18. Jia W et al. Nickel release from orthodontic arch wires and cellular immune response to various nickel concentrations. *J of Biomedical Materials Research (Applied Biomaterials)* 1999; 48: 488 – 495.
19. International Programme on Chemical Safety (IPCS) Environmental Health Criteria 1991; 108. Nickel. World Health Organization, Geneva International Program on Chemical Safety (IPCS).
20. Bishara S E, Barret R D, Selim M I Biodegradation of orthodontic appliances. Part II. Changes in the blood level of nickel. *Am J Orthod Dentofac Orthop* 1993; 103: 115 – 119.
21. Ronny Fors, MauritsPersson. Nickel in dental plaque and saliva in patients with and without orthodontic appliances. *Eur. J. Orthod* 2006; 28(3):292-7.
22. Mayworm CD, Leao MH, Bastianfl, Artificial saliva sorption for two hybrid nano particle resin based restorative dental composites. *J. Enpromer*. 2005, 4(2): 41-52.
23. Kerosuo, H., G. Moe, and E. Kleven. In vitro release of nickel and chromium from different types of simulated orthodontic appliances. *Angle Orthod* 1995; 65(2):111–116.
24. MajaKuhta, DubravkoPavlin, Martina Slaj, SuzanaVarga, Marina Lapter-Varga, and MladenSlaj (2009) Type of Arch wire and Level of Acidity: Effects on the Release of Metal Ions from Orthodontic Appliances. *Angle Orthod* 2009; 79 (1). 102-110.