Nickel and Chromium Ions Release from Stainless Steel Bracket Immersed in Fluoridated Mouthwash

Ida Bagus Narmada[1], Ria Anbar Baya[2], Thalca Hamid[3]*

1. Departement of Orthodontics, Faculty of Dental Medicine, Universitas Airlangga, Surabaya, Indonesia.
2. Resident of Departement of Orthodontics, Faculty of Dental Medicine, Universitas Airlangga, Surabaya, Indonesia.
3. Departement of Orthodontics, Faculty of Dental Medicine, Universitas Airlangga, Surabaya, Indonesia.

Abstract

Stainless steel (SS) orthodontic brackets can release metal ions into oral cavity. Fluoridated mouthwashes are often recommended to orthodontic patients to reduce the risk of white-spot lesions around their brackets. However, information regarding the effect of fluoridated mouthwashes on nickel (Ni) and chromium (Cr) release from SS brackets are not available.

To determine the amount of Ni and Cr ions release immersed in fluoridated mouthwash and non-fluoridated mouthwash.

120 AO brackets and 120 Protect brackets were each divided into 2 equal groups, immersed in fluoridated mouthwash group and non-fluoridated mouthwash group for 24 days. Element composition of brackets were analysed using Energy Dispresive X-Ray Spectroscopy (EDX) before being immersed in the mouthwash. The amount of Ni and Cr ion release were measured with an inductively coupled plasma spectrometer (ICP). For statistical analysis, independent t-test was used.

Element composition of brackets using EDX showed that the level of Ni in AO brackets were higher than in Protect brackets, while the level of Cr in AO brackets were smaller. ICP analysis showed that Ni and Cr release from AO and Protect brackets in fluoridated mouthwash was significantly higher than non-fluoridated mouthwash.

Fluoridated mouthwashes should not be given to orthodontic patient, especially for patient who have Ni and Cr allergy reaction.

Experimental article (J Int Dent Med Res 2018; 11(1): pp. 294-298)

Keywords: Fluoridated mouthwashes, Ni ion release, Cr ion release, Stainless Steel bracket.

Received date: 10 October 2017 **Accept date:** 26 October 2017

Introduction

The metal bracket is the most common bracket chosen from all types of bracket available, one of them is SS bracket.[1] According to Patel et al[2], the main components of SS are 8-12% nickel (Ni) and 17-22% chromium (Cr). Ni and Cr composition in SS bracket make it flexible and corrosion resist, but there are a lot of studies have reported their toxic, cariogenic, and hypersensitivity potency. Faccioni et al confirmed that in 50 fix orthodontic patients, there are 3-4 times Ni level increases which lead to DNA damage in oral mucosa. The mean daily intake of Cr from food source is 280 µg and for Ni is 200 – 300 µg, while Ni concentration in drinking water generally below 20 µg/L and for Cr is around 0,43 µg/L.[3-5]

In the corrosion process of SS bracket in oral cavity, there is metal ion release that could accumulated in the body and have carcinogenic, allergenic, mutagenic, cytotoxic, and may be the reason for some other diseases. Ten percents of population have sensitive reaction to Ni. Peltonen reported that female 10 times more sensitive to Ni exposure than male. A study using human cell culture showed a grave cytotoxic from Ni exposure and a milder cytotoxic effect from Cr.[6-8]

Fix appliance orthodontic treatment can raise the caries risk due to the difficulties in cleaning the dental plaque and debris, therefore practitionners usually suggest the usage of mouthwash to the patient with severe oral health and high risk of caries. The usage of fluoridated mouth wash and tooth paste during the

Corresponding author:
Ida Bagus Narmada, DDS., Ph.D., Sp. Ort (K)
Departement of Orthodontics Faculty of Dental Medicine, Universitas Airlangga, Mayjen. Prof. Dr. Moestopo 47, Surabaya, Indonesia 60132,
E-mail: ida-b-n@fkg.unair.ac.id

orthodontic treatment was recommended to minimize the risk of white spot around the brackets. Lee et al reported that fluoride ion in mouthwash caused the degradation of SS bracket surface which resulted in ion releases and corrosion.[9,10]

Fluoride ion as prophylactic agent was reported to cause corrosion and discoloration, however up to date, further information regarding the effect of fluoride content in mouthwash used by patient with fix orthodontic appliance is yet to be known. Therefore, this research was conducted in order to determine the amount of Ni and Cr ions release immersed in fluoridated mouthwash and non-fluoridated mouthwash.

Materials and methods

Procedures

This is an experimental laboratory research using 240 orthodontic brackets of the right regio from the AO™ (American Orthodontics, Wisconsin, USA) and Protect™ (Zheijiang Protect Medicl Equipment Co, Ltd., China) prescription. The brackets were equally divided into 4 groups: 60 AO brackets and 60 Protect brackets were immersed in 15 ml fluoridated mouthwash, while the rest of each type were immersed in 15 ml non-fluoridated mouthwash for 24 days at temperature of 37°C.

The brackets were dried and the element composition were analysed using Energy Dispersive X-Ray Spectroscopy (EDX) (Amatek, Nagoya, Japan). In the day 24, the solutions inside each tube at each experimental period were analysed by inductively coupled plasma (ICP) spectrometer (Perkin Elmer Inc., Massachusetts, USA) to determine Ni and Cr content.

Statistical analysis

The Ni and Cr released values from AO and Protect brackets immersed in two different solutions over a period of 24 days were analysed with SPSS ver. 17 (IBM Company, New York, USA) using the independent T-test. Tests were performed with a 5% level of significance.

Results

SS Bracket Element Composition Analysis Results

The element compositional of SS brackets before being immersed was analysed using EDX. Figure 1 showed in AO bracket, the highest element level is Fe, followed by C, Cr, Ni, O, Cu, Al, Si, and Mn subsequently. While in Protect bracket, the highest is Fe, followed by Cr, Mn, C, Cu, O, Ni, Al and Si subsequently. Ni level was higher in AO (6.87) bracket than in Protect bracket (2.39). In contrast, Cr level was higher in Protect bracket (14.45) than in AO bracket (12.53).

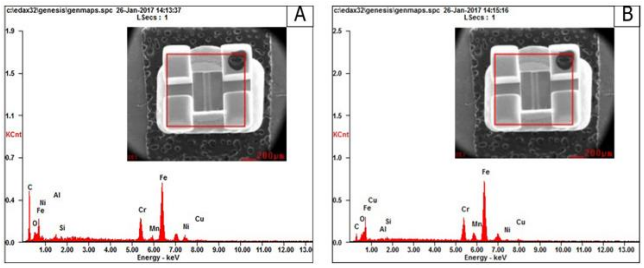

Figure 1. Element Composition Analysis Results using EDX qualitatively: **A.** AO bracket before being immersed, **B.** Protect bracket before being immersed.

Ni and Cr Ion Releases Analysis Results

Ion release analysis was done to mouthwash liquid after 24 days of bracket immersion. Table 1 showed that the mean of Ni and Cr ion releases in AO and Protect bracket was greater in fluoridated mouthwash than the non-fluoride one.

Variable		Fluoridated	Non-fluoridated	p value
Bracket	Ion	Mean±SD	Mean±SD	
AO	Ni	0,686±0,008	0,614±0,042	0,042*
	Cr	0,008±0,002	0,002±0,001	0,009*
Protect	Ni	0,343±0,084	0,186±0,013	0,033*
	Cr	0,482±0,030	0,161±0,025	0,000*

Table 1. Independent T-test analysis results of Ni and Cr ion release in Ao and Protect bracket immersed in the fluoridated and non-fluoridated mouthwashes for 24 days. *Significant if p<0,05.

There was a significant difference of Ni and Cr ion release in AO and Protect brackets immersed in fluoridated mouthwash compare to the rest immersed in non-fluoridated mouthwash for 24 days (p<0,05).

Table 2 showed a significant difference of Ni ion release between AO and Protect bracket, either immersed in fluoridated mouthwash (p= 0.002) or in non-fluoridated mouthwash (*p*= 0,000). The same result was found in Cr ion release with p = 0,001 in fluoridated mouthwash and p = 0,008 in non-fluoridated mouthwash.

Variabel		AO	Protect	P value
Mouthwash	Ion	Mean±SD	Mean±SD	
Fluoridated	Ni	0,686±0,008	0,343±0,084	0,002*
	Cr	0,008±0,002	0,482±0,030	0,001*
Non-fluoridated	Ni	0,614±0,042	0,186±0,013	0,000*
	Cr	0,002±0,001	0,161±0,025	0,008*

Table 2. Independent T-test analysis results of Ni and Cr ion release between Ao and Protect brackets immersed in the fluoridated and non-fluroidated mouthwashes for 24 days.
* Significant if p<0,05.

Disscussion

Fix orthodontic appliances are often used to treat patients with maloclussion in order to improve their quality of life. Brackets are the main component of fix orthododontic treatment. This research used SS bracket as it is widely used in clinical treatment due to its positive physical and mechanical properties.[11] Despite the widely usage, fix orthodontic appliance could potentially increase the caries risk as it is hard to clean. Therefore, practicionners often suggest the usage of mouthwash to patient with bad oral hygiene and high caries risk. O'Reilly and Featherstone reported the usage of tooth paste alone is inadequate to prevent caries development, orthodontic patient need to use fluoridated mouthwash (0,05% NaF) daily in combination with fluoridated tooth paste.[12] Previous study showed for oral hygiene protection in fix orthodontic patient, the usage of interdental brush and mouthwash are needed along with the conventional tooth brush and tooth paste.[13]

Mouthwash are used twice a week for one minute, however it is recommended to avoid eating, drinking, and gargling for some time after usage in order to preserve the mouthwash component in the mouth longer. It is hard to determine precisely the contact duration between bracket and mouthwash, but there is an assumption that in each 30-60seconds, the fluoride level in saliva increases for 2-4 hours. Orthodontic treatment usually done in a long period, for about 2 years, therefore 24 days is the total duration assumption to immerse the brackets into the mouthwash. It has been reported that ion release happened in day 7 and peaked in the 4th week, therefore, in this study the ion release was monitored in day 24.[7,14]

The purpose of this study is to determine the amount of Ni and Cr ions release immersed in fluoridated mouthwash and non-fluoridated mouthwash. There are several factors that affect the metal ion release from fix orthodontic appliance such as the composition of alloy metal, oral cavity pH, oxygen, and the duration of immersion. The ion releases of Ni and Cr are also predisposed by the present of fluoride ions and the contact duration between brackets and mouthwash.[15]

In this study, there was a higher level of Ni release from both AO and Protect brackets immersed for 24 days in fluoridated mouthwash than in non-fluoridated mouthwash. The same result was obtained for Cr ion variable. A higher ion release in fluoridated mouthwash was caused by fluoride as an aggressive ion which is able to destruct the oxide layer (Cr_2O_3) on the brackets surface. The oxide layer has the role to inhibit the corrosion process on the SS brackets.[15] These results correspond to a study by Rafeeq et al, which was done by immersing the bracket ligatured in NiTi and SS wires in fluoridated and non-fluoridated mouthwash.[16] According to that study, Ni release was higher in fluoridated mouthwash than in non-fluoridated mouthwash. In line with the study done by Kocijan et al, which evaluated passive layer formed on SS bracket immersed in artificial saliva with fluoride addition, stated that there was composition changing on passive layer and cause more rapid destruction.[17]

This research evaluated the difference of Ni and Cr ion release from both AO and Protect brackets. A higher Ni release occurred in AO brackets immersed in fluoridated mouthwash, while higher Cr release occurred in Protect bracket immersed in fluoridated mouthwash. It is related to the Ni and Cr element composition in the bracket which analysed using EDX before the immersion. The results showed that Ni level was higher in AO bracket than in Protect, while Cr level was higher in Protect bracket than in AO. This implied that higher Ni and Cr levels in the immersed brackets lead to higher Ni and Cr releases.

SS brackets with higher Ni composition will release more Ni ion as Ni atom is not strongly bonded to other metal atom, so the possibility of Ni released from SS alloy increase.[4,5] According to Danaei et al, Ni and Cr were also found in human body from food intake. Daily Ni intake from food was 300-500 ug and Cr 5-100 ug, while Ni concentration in the consumption water is under 0.43 ug/L.[5] A study done by Kerusuo et

al reported that Ni and Cr concentration in the saliva of fix orthodontic patient were 1-55 ppb for Ni and 1-1.61ppb for Cr, whereas Ağaoğlu et al reported that Ni level in saliva was 4.12 – 11.53 ppb and Cr 0.53-1.53 ppb, which were lower than intake level from food.[18,19] According to Huang et al, Ni allergic response threshold is 600-2500 ug per day.[20]

In this study, the highest level of Ni release was in fluoridated mouthwash, 0.686 ppm or 686 ug/L if the value was converted and for Cr was 0.482 ppm (482 ug/L). It exceeds the minimum Ni allergic response threshold.

The mouthwashes used in this research have similar low pH level therefore the difference level of ion release was not caused by the different pH level. There are several other corrosive compositions besides fluoride. Danaei et al reported that in acid condition, corrosion could be easily occurred even in a low fluoride concentration. General mechanism of SS bracket corrosion is started with the loss of passive layer consisted of Cr oxide and Cr hydroxide which formed by the contact of oxygen and SS surface.[5] Corrosion occurred is crevice corrosion due to continuous exposure.

Ni has an important role to stabilize austenitic and to protect from corrosion. Although the toxic effect of Ni is widely known, it is hard to eliminate that element in SS bracket. Cr in SS bracket has function as corrosion protection, despite its toxic effect that can cause respiratory cancer. Furthermore, molybdenum (Mo) and cooper (Cu) addition in SS could improve its resistance to temperature changes and corrosion, while the addition of Cu and aluminium (Al) could improve its hardness. From all the composite elements, Ni and Cr were the most reported to cause toxic effect, therefore this research focused in Ni and Cr release from SS bracket.[4,5]

Conclusions

Ni and Cr ion release level was higher in fluoridated mouthwash than in non-fluoridated mouthwash. While the higher level of Ni release found from AO brackets which contain more Ni in its bracket, higher level of Cr release was found from Protect brackets which contain more Cr in its bracket. Fluoridated mouthwashes should not be given to orthodontic patient, especially for patient who have Ni and Cr allergy reaction.

Declaration of Interest

The authors report no conflict of interest and the article is not funded or supported by any research grant.

References

1. Maringka G, Herda E. The Duration of Bracket Detachment at Public Health Center Jakarta and Dental Hospital Universitas Indonesia. International Journal of Dental and Medical Research. 2016;9(Special Issue, U.I. 1st International Workshop on Dental Research):345-50.
2. Patel R, Bhanat S, Patel D, Shah B. Corrosion Inhibitory Ability of Ocimum Sanctum Linn (Tulsi) Rinse on Ion Release from Orthodontic Brackets in Some Mouthwashes: An Invitro Study. National Journal of Community Medicine. 2014;5(1):135-9.
3. Faccioni F, Franceshetti P, Cerpelloni M, Fracasso ME. In Vivo Study in Metal Release from Fixed Orthodontic Appliance and DNA Damage in Oral Mucosa Cells. Am J Orthod Dentofac Orthoped. 2003;124(6):687-93.
4. Oh KT, Choo SU, Kim KM, Kim KN. A Stainless Steel Bracket for Orthodontic Application. Eur J Orthod. 2005;27(3):237-44
5. Danaei SM. Safavi A, Roinpeikar SM, Oshagh M, Iranpour S, Omidekhoda M. Ion Release from Orthodontic Brekets in 3 Mouthwashes; An In-Vitro Study. Am j orthod dentofacial orthop. 2011;139(6):730-4.
6. Al Subari R, Abdulwali N, Bellaouchou A, Guenbour A, Bachir AB, Merzouk N. Influence of Chlorhexidine Mouthwashes on Corrosion Resistance of Ni–Cr Dental Casting Alloys. Journal of International Dental and Medical Research. 2012;5(2):62-72.
7. Peltonen L. Nickel Sensitivity in the General Population. Contact Dermatitis. 1979;5(1):27-32.
8. Bardal E. Corrosion and Protection. London: Springer-Verlag; 2004.
9. Hussain SF, Asshaari AA, Osman BAB, AL-Bayati FH, Amir AB. In Vitro - Evaluation of Biodegradation of Different Metallic Orthodontic Brackets. Journal of International Dental and Medical Research. 2017; 10(1):76-83.
10. Lee TH, Huang TK, Lin SY, Chen LK, Chou MY, Huang HH. Corrosion Resistance of Different Nickel-Titanium Archwires in Acidic Fluoride-Containing Artificial Saliva. Angle Orthod 2010; 80(3):547-53.
11. Quintao CCA, Brunharo IHVP. Orthodontic Wires: Knowledge Ensures Clinical Optimization. Dental Press J. orthod. 2009;14(6):144-57.
12. O' Reilly MM, Featherstone JD. Demineralization and Remineralization around Orthodontic Appliance: An in Vivo Study. Am J Orthod Dentofac Orthop. 1987;92(1):33-40.
13. Eliades T, Athanasion UAE. In Vivo Aging of Othodontic Alloy: Implication for Corrosion Potential, Nickel Release and Biocompability. Angle orthod. 2002;72(3):222-37.
14. Bourzgui F, Sebbar M, Hamza M. Orthodontics and Caries. In: Naretto S eds. Principles in Contemporary Orthodontics. Croatia: InTech Europe;2011:309-26.
15. Porcayo-Calderon J, Casales DM, Salinas B, Martines G I. Corrosion Performance of Fe-Cr-Ni in Artificial Saliva and Mouthwash Solution. Bioinorg Chem Appl. 2015;2015:1-14.
16. Rafeeq RA, Saleem AI, Nissan LN. Ion Release from Fixed Orthodontic Appliance in Two Different Mouthwashes. J Bagh College Dentistry. 2014;26(4):152-5.
17. Kocijan A, Merl DK, Jenko M. The Corrosion Behavior of Austenitic and Duplex Stainless Steel in Artificial Saliva with the Addition of Fluoride. Corrosion Science. 2013;53(2): 776-783.
18. Kerosuo H, Moe G, Hensten-Pettersen A. Salivary Nickel and Chromium in Subjects with Different Types of Fixed Orthodontic Appliance. Am J Orthod Dentofacial Orthop. 1997;111(6):595-8.

19. Ağaoğlu G, Arun T, Izqi B and Yarat A. 2001. Nickel and Chromium Level in the Saliva and Serum of Patients with Fixed Orthodontic Appliances. Angle Orthod. 2001;71(5):375-9.
20. Huang HH, Chiu YH, Lee Th, Wu Sc, Yang HW, Su KH. Ion Release from Niti Orthodontic Wires in Artificial Saliva with Various Acidities. Biomaterials. 2003;24(20):3585-92.