Evaluation of the Corrosive Impact of Probiotic and Isotonic Beverages on Dental Archwires

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ABSTRACT
The aim of this in vitro study was to investigate the effect of probiotic and isotonic drinks on chromium (Cr) and nickel (Ni) release from dental archwires. The conventional stainless steel dental archwires were used in this study, with 0.8 cm diameter, and 5 cm long from each sample. Total samples are 54 pieces dental archwires. The samples then divided into two major groups: (1) the probiotic (T1); and (2) isotonic (T2) drinks. Each major group consist three subgroups, such as: for the T1: (1) T1,1: as a negative control group (samples were immersed in saline solution); (2) T1,2: as a positive control group (samples were 1% lactic acid); (3) T1,3: as a treatment group (samples were immersed in normal saline + probiotic drink); and for the T2: (1) T2,1: as a negative control group (samples were immersed in saline solution); (2) T2,2: as a positive control group (samples were immersed in 1% lactic acid); (3) T2,3: as a treatment group (samples were immersed in normal saline + isotonic drink). After the immersion testing, there was a significance difference in Cr and Ni release from dental archwires between the subgroup of treatments from both probiotic and isotonic drinks (Kruskal-Wallis test followed by Mann-Whitney test; $P < 0.05$). In conclusion, the present study demonstrated that both probiotic and isotonic drinks induced the releasing of Cr and Ni from dental archwires.

Keywords: Chromium, Dental Archwires, Isotonic Drinks, Nickel, Probiotic Drinks.

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INTRODUCTION

Orthodontics is the oldest specialty that has undergone the drastic transformation in the past few decades. In contrast to the past, in the present era, the primary concern of adult patients has improved aesthetics during treatment and good treatment results. Because of that, the orthodontic practice ultimate goal is the development of an appliance combining both aesthetics and efficiency. Due to the significantly increasing demand for esthetics during fixed appliance therapy, esthetic brackets, as well as dental archwires, have been introduced[1].

The dental archwires are the main force system in orthodontics, they have been experimentally tested many times over. Traditionally, the dental archwires were manufactured with Stainless steel or Chrome-Cobalt alloy[2]. The Stainless steel dental archwires contained a high content of chromium (Cr), which contributed to its corrosion resistance. These wires is composed of mainly iron (Fe) along with 17-20% Cr, 8-12% nickel (Ni), and up to 0.15% carbon (C)[3]. Because these appliances are placed in a long time in the mouth, they can be exposed to electrochemical reactions, mechanical forces of mastication, and generalized wear. All these phenomena are able to accelerate the different types of corrosion processes that can take place in the patient's mouth, and the degradation products from archwires are then released into the oral environment[4].

Metal corrosion is an electrochemical process in which a metal surface exposed to a conducting aqueous electrolyte usually becomes the site for two simultaneous chemical reactions: oxidation and reduction[5]. One of the main causes of corrosion is acidic conditions. It is well known that in the oral cavity, acids could be produced by intraoral bacteria and from beverages, such as isotonic and probiotic drink[6-8].

Sports drink or popularly commercialised as isotonic drinks dominates the total volume and value sales of functional drinks in many countries. The demand for isotonic drinks is on the high scale as they are not only consumed by those who are involved in physical indoor and outdoor activities, but also preferred in official meetings and social events. The change in the life style of the modern urban societies also contributes to the tremendous rise in isotonic drinks consumption[9]. Since sports drinks are usually ingested a sip at a time, the drinks' residue remains in the oral cavity for quite some time. This can influence tooth health because beverages such as sports drinks may have a low pH value, which in turn is related to dental erosion and metal corrosion[10].

Probiotics are defined as living microorganisms, principally bacteria, that are safe for human consumption and, when ingested in sufficient quantities, have beneficial effects on human health, beyond basic nutrition. This definition has been approved by the United Nations Food and Agriculture Organization (FAO) and the World Health Organization (WHO)[8]. The global market for probiotic ingredients, supplements and food were worth $14.9 billion in 2007 and it was expected to reach 15.9 billion in 2008, and 19.6 billion in 2013, representing a compound annual growth rate of 4.3 %.[11] The increasing consumption of these drinks could be expected to affect oral health or dental tools.

As mentioned above, both isotonic and probiotic drinks could be expected to affect dental tools, such as dental archwires. It is thought to be caused by the acidic properties in both these drinks that can trigger corrosion processes. These process can adversely affect human health and for dental archwire itself. Corrosion on metal can cause discoloration of the metal surface, reduction in strength and dimension metals that can cause breakage of metal. For human health, the metal from the corrosion can cause an allergic reaction[11].

Based on this background, this present study aims to investigate the amount of ion release from dental archwires under the influence of both isotonic and probiotic drinks. In addition, the ion was investigated in this present study are Cr and Ni.

MATERIAL AND METHODS

Experimental models

This research is a quasi-experimental design with posttest only control group using conventional dental archwires. These conventional dental archwires were made of Fe, Cr, Ni, and C. The wire diameter is 0.8 cm. The wire is cut along 5cm. Wire length refers to the average length of the labial bow on removable orthodontic treatment. Then do the bending in the middle of the wire to form a semi-circle and streaking along 1cm on each sample. There were two major groups in this experiment, the probiotic (T1) and isotonic drink (T2). Each major group consists three subgroups. The subgroups were as follows; for the T1: (1) T1,1: as a negative control group (samples were immersed in saline solution); (2) T1,2: as a positive control group (samples were 1% lactic acid); (3) T1,3: as a treatment group (samples were immersed in normal saline + probiotic drink); and for the T2: (1) T2,1: as a negative control group (samples were immersed in saline solution); (2) T2,2: as a positive control group (samples were immersed in 1% lactic acid); (3) T2,3: as a treatment group (samples were immersed in normal saline + isotonic drink). Each subgroup consists 9 dental archwires. So, in this experimental study, 54 dental archwires were used. The samples from the T1 group were immersed for 24 hours, while the T2 group was immersed for 48 hours. The difference of the immersion time between those group was caused by the difference result from the conversion analysis between the average consumption of each drink and the use of dental wires. After treatment, the water immersion result from each sample was undergoing to Cr and Ni content analysis. *Estimation of chromium (Cr) level*

The Cr content analysis of the water immersion result was done using complexometry methods.[12] Prepare a sample solution by diluting 25 ml sample with 5 ml of HCl. Then, added 20 ml KI 1 N, 5 ml of HCl, and 20 ml of aquades, and let stand for 5 min. Titrated with 0.1 N of sodium thiosulphate solution. Added 3 ml of starch and continue the titration until the blue color of the solution was disappear. The Cr content is then calculated using the oxide redox meter. *Estimation of nickel (Ni) level*

The Ni content analysis of the water immersion result was done using complexometry methods.12 Prepare a sample solution by diluting 10 ml sample with 5 ml of 1M ammonium chloride, and 10 ml aquadest. Add Murexide indicator and 2 drops of an ammonium hydroxide solution until the solution is turned into yellow. Titrated with 0.01 M EDTA solution until the end point of the titration. Add 2 drops of ammonium hydroxide solution and continue the titration until the color of the solution was changed to redviolet. Ni content was calculated following to equation: W_{Ni} (mg) = M_{EDTA} x V_{EDTA} x MW_{Ni} where W_{Ni} is a Ni weight, M_{EDTA} is the molarity of EDTA, V_{EDTA} is the volume of EDTA, and MW_{Ni} is the molecule weight of Ni.

Statistical evaluation

The results were expressed as mean ±SE for three replicates. The significance of mean differences of Cr and Ni content between treatment and control groups were statistically compared using Kruskal-Wallis test and followed by a Mann-Whitney test for multiple range test. Significance was set at $P<0.05$. The software used for the data analysis were the Statistical Package for the Social Sciences (SPSS) version 16.0 and Microsoft Excell 2010 for Windows Vista.

RESULTS

This present study which was undertaken to assess the amount of Cr and Ni release from dental archwires under the influence of both probiotic and isotonic drinks. Figure 1 represented the mean values±standard error (mean±SE) of the amount of Cr release from dental archwires under the influence of probiotic drinks. Dispersion of measured values around each mean varied from 0.026 to 0.037. After the immersion testing, there was a significance difference in Cr release from dental archwires between the subgroup of treatments (KruskalWallis test; $P < 0.05$). Mann-Whitney test results show that there are significant differences between each subgroup of treatments (table 1). The amount release of Cr from dental archwires under different immersion treatment are presented in the Figures 2. After the dental archwires immersed in lactic acid and isotonic drinks, the amount release of Cr from dental archwires seems to be an increase compared to the normal saline immersion (Figure 2). The statistical analysis test results show that the increasing of the amount release of Cr from dental archwires was statistically significant (Kruskal-Wallis test; $P < 0.05$). Mann-Whitney test results show that there are significant differences between all subgroup of treatments (table 1).

Figure 3 represented the mean values±standard error (mean±SE) of the amount of Ni release from dental archwires under the influence of probiotic drinks. Dispersion of measured values around each mean varied from 31.300 to 122.500. After the immersion testing, there was a significance difference in Ni release from dental

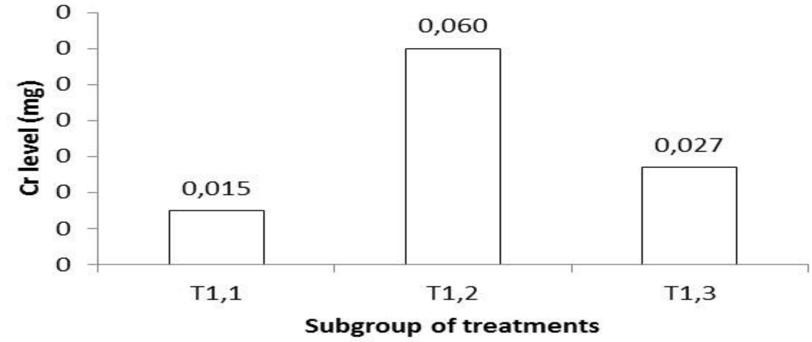

Figure 1: Comparison of the amount release of Cr from dental archwires between subgroup of treatments. $T_{1,1}$: normal saline; $T_{1,2}$: 1% lactic acid; and $T_{1,3}$: normal saline + probiotic drinks.

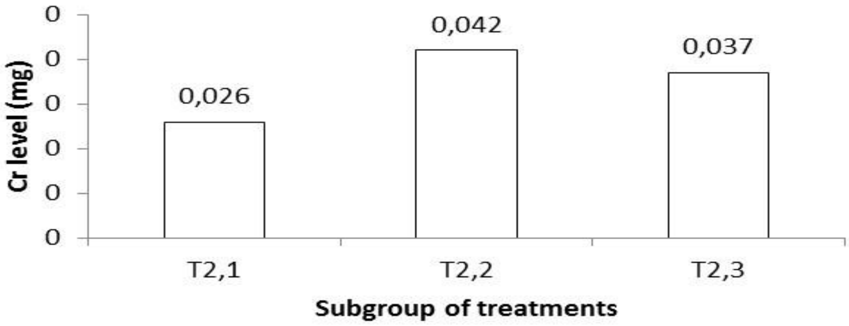

Figure 2: Comparison of the amount release of Cr from dental archwires between subgroup of treatments. $T_{2,1}$: normal saline; $T_{2,2}$: 1% lactic acid; and $T_{2,3}$: normal saline + isotonic drinks.

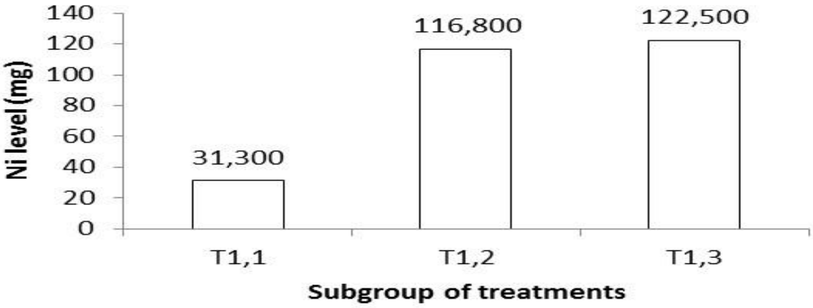

Figure 3: Comparison of the amount release of Ni from dental archwires between subgroup of treatments. $T_{1,1}$: normal saline; $T_{1,2}$: 1% lactic acid; and $T_{1,3}$: normal saline + probiotic drinks.

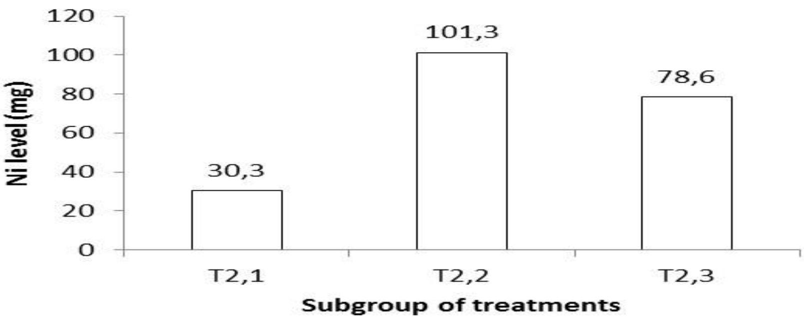

Figure 4: Comparison of the amount release of Cr from dental archwires between subgroup of treatments. $T_{2,1}$: normal saline; $T_{2,2}$: 1% lactic acid; and $T_{2,3}$: normal saline + isotonic drinks.

archwires between the subgroup of treatments (Kruskal- The amount release of Ni from dental archwires under Wallis test; $P < 0.05$). Mann-Whitney test results show that different immersion treatment are presented in the Figures there are significant differences between each subgroup of 4. After the dental archwires immersed in lactic acid and treatments (table 1). isotonic drinks, the amount release of Ni from dental Table 1: Mann-Whitney test results of the amount release of Cr and Ni from dental archwires between different subgroup of treatments.

Group Comparison	Cr		Ni	
	p-value	Interpretation	p-value	Interpretation
$T_{1,1}$-$T_{1,2}$	0.000	S	0.000	S
$T_{1,1}$-$T_{1,3}$	0.000	S	0.000	S
$T_{1,2}$-$T_{1,3}$	0.000	S	0.000	S
$T_{2,1}$-$T_{2,2}$	0.000	S	0.000	S
$T_{2,1}$-$T_{2,3}$	0.000	S	0.000	S
$T_{2,2}$-$T_{2,3}$	0.000	S	0.000	S

$T_{1,1}$: normal saline; $T_{1,2}$: 1% lactic acid; $T_{1,3}$: normal saline + probiotic drinks; $T_{2,1}$: normal saline; $T_{2,2}$: 1% lactic acid; and $T_{2,3}$: normal saline + isotonic drinks. Results presented as mean±SD. p-Values were calculated using the KruskalWallis test and followed by Mann-Whitney test; $p < 0.05$ was considered statistically significant.

archwires seems to be the increase compared to the normal saline immersion (Figure 4). The statistical analysis test results show that the increasing of the amount release of Ni from dental archwires was statistically significant (Kruskal-Wallis test; $P < 0.05$). Mann-Whitney test results show that there are significant differences between all subgroup of treatments (table 1).

DISCUSSION

The result of this present study indicated that probiotic drinks affect the release of Cr from dental archwires. But, the amount release of Cr seems to be lower in the probiotic group compared to lactic acid. This is because the Cr release can be inhibited by certain organic compounds.[13] It is well known that bacteria could produce several organic compounds. This is may be the reason why the release of Cr was lower compared to lactic acid[14].

The results of this present study also showed that the highest average release of Ni occurred in probiotic drinks group. The main reason why the probiotic drinks could cause the release of Ni is the lactic acid production by the lactic acid bacteria. It is in line with the results of Burns et al. study who found acetate, ketoglutaric, succinic and lactic acid which isolated from the aerobic culture can create corrosion of carbon steel[15]. The result also indicated that the release of Ni in probiotic drinks group was higher than group lactic acid group. This is because the levels of lactic acid that produced by lactic acid bacteria in probiotic drinks were higher than the lactic acid that used in this study.

The results of this present study revealed that the immersion in isotonic drinks can cause the release of Ni and Cr from dental archwires. The release of both Cr and Ni were found higher in the isotonic group compared to the normal saline group. This is because the isotonic drink contained a higher level of NaCl than NaCl itself. NaCl is a salt that can form a strong electrolyte solution if it were in the water. Cl- in NaCl solution can damage an oxide layer that can trigger corrosion processes[16-17]. If the content of NaCl in the solution is greater, the Cl- content will also increase, so the corrosion rate will be higher. The results of this present study are in line with the previous studies conducted by Wasono. That result study explained that the releasing of Cr and Ni from dental archwires was found to be higher in isotonic immersion that artificial saliva[16].

Interesting results are seen from the comparison of Cr and Ni release amounts between isotonic drinks and lactic acid. The release of Cr and Ni from dental archwires seems to be higher in a lactic acid group than isotonic drinks group. This is because the isotonic drinks contained magnesium carbonate ($MgCO_3$). $MgCO_3$ can react with water to form an alkaline solution. It will shift the pH to the neutral pH (closer to 7). This is the main reason why the corrosion rate of Cr and Ni in isotonic drinks was slower than lactic acid group[16,18].

In conclusion, the present study demonstrated that both probiotic and isotonic drinks induced the releasing of Cr and Ni from dental archwires. There is no doubt that the acidic nature of both probiotic and sports drinks has the potential to cause corrosion of the dental archwires. Future work in more clinically relevant conditions is vital for better comprehension.

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