Bulletin of Health,
Science and Technology
BHST
ISSN 0858-7531
Volume 14, Number 2, 2016 : 40-46

ION RELEASED FROM FASHION ORTHODONTIC BRACKETS AND STANDARDIZED ORTHODONTIC BRACKETS IN ARTIFICIAL SALIVA

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Abstract: Fashion orthodontics has becoming a trend in Thai teenager as to mimic the orthodontic looks not treatment. This has done through illegal and risking poorer oral hygiene and systemic condition. However, there is no academic evidence about this situation in fashion brackets. The purpose of this study was to compare the quantity of metal ions releasing from fashion and standardized orthodontic brackets in artificial saliva at pH 3.75 and pH 6.25. Samples were divided into 2 groups of standardized pre-adjustable brackets (3M/Unitek) and fashion brackets (randomly gathering from local market and social network in Thailand). Each samples comprised of 5 metal brackets. Samples were immersed in artificial saliva at pH 3.75, 6.25 and store in shaking incubator at 37oC for 28 days. The energy dispersive spectroscopy (EDS) was used to identify metal ions before immersion. Afterwards, the saliva was tested for Copper, Nickel, Iron, and Chromium ion using inductively couple plasma-optical emission spectroscopy (ICP-OES). All specimens were passed through surface analysis using scanning electron microscopy (SEM) both before and after immersion. Fashion brackets showed high amount of Ni ion released at pH 3.75 and pH 6.25 with 51751.67 and 4808.833 μg/L respectively. The ratio of Ni-ions released between standardized and fashion bracket at pH 6.25 was 1:20.5, for Cu ion was 1:4.8. At pH 3.75 Ni, Fe and Cr showed the ratio of 1:1,461, 1:4 and 1:8.7, respectively. In conclusion, significantly higher level of metal ions released from fashion orthodontic brackets than from standardized orthodontic brackets. Especially Ni ion released from the fashion brackets in both pH 3.75 and pH 6.25 were 100 times over the daily dietary intake and double times for causing allergic reaction.

Keywords: Fashion brackets; Ion release

บทคัดย่อ: การจัดฟันแฟชั่นกลายเป็นค่านิยมในวัยรุ่นไทย ซึ่งเป็นสิ่งผิดกฎหมายและมีอันตรายจากการใช้วัสดุไม่ได้มาตรฐาน โดยอาจมีการปล่อยไอออนโลหะที่ก่อให้เกิดพิษ อย่างไรก็ตามยังไม่มีการศึกษาเกี่ยวกับแบร็กเกตจัดฟันแฟชั่น ดังนั้นการศึกษานี้มีขึ้นเพื่อศึกษาเปรียบเทียบองค์ประกอบของโลหะผสมในแบร็กเกตจัดฟันที่สุ่มซื้อจากห้องตลาดทั่วประเทศไทย และแบร็กเกตจัดฟันมาตรฐานของบริษัทยูนิเทคสามเอ็ม ลักษณะสัณฐานวิทยา และปริมาณไอออนของโลหะที่ถูกปลดปล่อยในภาวะจำลองช่องปาก การศึกษาแบ่งเป็น 2 กลุ่ม กลุ่มที่ 1 แบร็กเกตจัดฟันมาตรฐาน และกลุ่มที่ 2 แบร็กเกตจัดฟันแฟชั่น โดยอุปกรณ์ทั้งหมดถูกแช่ในน้ำลายเทียมค่าความเป็นกรดด่างเท่ากับ 3.75 และ 6.25 เป็นเวลา 28 วัน ประเมินด้วยกล้องจุลทรรศน์แบบส่องกราด และการวิเคราะห์องค์ประกอบธาตุโดยใช้การกระจายพลังงานของรังสีเอ็กซ์ จากนั้นมีการวัดปริมาณธาตุ ทองแดง นิเกิล เหล็ก และโครเมียม ด้วยเครื่องมือวิเคราะห์ปริมาณธาตุและโลหะหนัก โดยใช้สถิติการทดสอบความแตกต่างของค่ากลางของสองประชากรไม่อิสระ จากการทดลองพบว่าแบร็กแกตจัดฟันแฟชั่นมีการปลดปล่อยนิเกิลในปริมาณสูงถึง 51751.67 ไมโครกรัมต่อลิตร และ 4808.833 ไมโครกรัมต่อลิตร ที่ค่าความเป็นกรดด่าง 3.75 และ 6.25 ตามลำดับ และเมื่อเปรียบเทียบอัตราส่วนการปลดปล่อยไอออนระหว่างแบร็กเกตจัดฟันแฟชั่นและแบร็กเกตจัดฟันมาตรฐาน พบว่าที่ค่าความเป็นกรดด่าง 6.25 มีการปลดปล่อยไอออนนิเกิล และทองแดง 20.5 และ 4.8 เท่าตามลำดับ และที่ค่าความเป็นกรดด่าง 3.75 มีการปลดปล่อยไอออนนิเกิล เหล็ก และโครเมียม 1,461 4 และ 8.7 เท่าตามลำดับ จึงสรุปได้ว่ามีการปลดปล่อยโลหะหนักจากแบร็กเกตแฟชั่นสูงกว่าแบร็กเกตที่ได้มารตรฐานอย่างมีนัยสำคัญทางสถิติ โดยเฉพาะการปลดปล่อยไอออนนิเกิล ซึ่งพบมีปริมาณมากเกินปริมาณความต้องการของร่างกาย 100 เท่า และเป็นสองเท่าของค่าที่ทำให้เกิดอาการแพ้

คำสำคัญ: แบร็กเกตจัดฟันแฟชั่น, การปลดปล่อยไอออน

INTRODUCTION

Thailand was stated to become the first country to have orthodontics as a non-medical treatment (Vachirarojpisarn, 2009). This so-called "fashion orthodontics" trend has drawn attention from all over the world (Vachirarojpisarn, 2009; Satravaha, 2005). The fashion orthodontic appliances are replicas of standardized appliances in terms of their shapes and appearances. Rityoue and Sasawongsaroj (2008) reported that the situation of fashion orthodontics had developed much further in uncontrollable manners.

Many previous studies demonstrated that various types of heavy metals were released from orthodontic appliances through long period of treatments. Considerable quantities of heavy metals had been released from the appliances as products because of corrosion (Locci et al, 2000). According to a study by Kuhta et al (2009), Cu, Fe, Ni, Cr, Zn were released from stainless steel wire and the largest number of ion was released during the first week of appliance immersion. Also, types of releasing ion depended on wire composition but their quantities were not proportional to the content of metal in the wire. An experiment on orthodontic brackets by Huang et al (2004) also showed similar results. They found that copper ion was the highest amount followed by Ni, Cr, Fe, Cu, Co, and Mn. Moreover, various experiments showed that lowering of pH and increasing immersion time increased metal ions release (Huang et at, 2003, 2004; Staffolani et al, 1999). According to Staffolani et al (1999), At the same pH level either organic or inorganic content demonstrated no difference in metal ion released. Furthermore, releasing of metal ion in dynamic condition (functional stress) found higher nickel released than in static condition (Kerosuo et al, 1995). Also, a larger number of metal ions released was found from recycled brackets compared to that of newer brackets (Huang et at, 2004). A few experiments were performed in vivo with various outcomes, as the result of Amini et al (2012) stated that an increased in nickel ions released in those receiving orthodontic treatment compared to those who did not. In contrary, the study of Eliades et al (2003) stated no significant difference.

However, there is no academic evidence about this situation in fashion brackets. Currently, illegal businesses had been manufacturing orthodontic appliances in various areas and had been spreading through social network markets (Vachirarojpisarn, 2009; Satravaha, 2005). Therefore, this study was to create the appropriate viewpoint by guiding the public away from this harmful act and to propose solutions for this situation.

The purpose of the study was to investigate the differences in quantity of metal ions release from fashion and standardized orthodontic appliances in artificial saliva.

MATERIALS AND METHODS

Samples were divided into 2 groups of standardized pre-adjustable brackets (3M/Unitek) and fashion brackets (randomly gathering from local market and social network in Thailand). Each group was split to immerse in modified Fusayama artificial saliva at pH 3.75 and 6.25. All specimens were cleaned in ultrasonic cleaning bath and rinsed with 70% alcohol before the immersion tests and separately immersed for 28 days in shaking incubator (n=6).

Surface Characterization analysis

Surface morphology and surface elemental compositions of the non- immersed were observed by scanning electron microscope (SEM) with an energy-dispersive spectrometer (EDS) (Jeol, Japan) before immersion.

Inductively coupled plasma optical emission spectroscopy analysis

The collected artificial saliva samples were subjected to Inductive Coupled Plasma-Optical Emission Spectroscopy (ICP-OES) (optima 7300 DV, Perkin elmer, USA). Approximately of 10 ml of experimental saliva was added in a vessel and saliva sample was dried under heating with infrared radiation. The Cr, Cu, Fe and Ni contents were determined using calibration curves. An internal standard mixing kit (Perkin elmer, USA) was employed for introducing the internal standard solution and the non-immersed artificial saliva was used as the blank.

Statistical Analysis

The log10 of results were tested for normality of distribution using Shapiro-Wilk's normality test. All samples were normally distributed hence paired-samples T tests was used to test for significant.

RESULTS AND DISCUSSION

Surface Characterization analysis

Figure 1 showed SEM micrographs before and after immersion in artificial saliva (pH 3.75) at 5000x. All samples showed the similar patterns of longitudinal shallow grooves surrounding with homogenous surfaces.

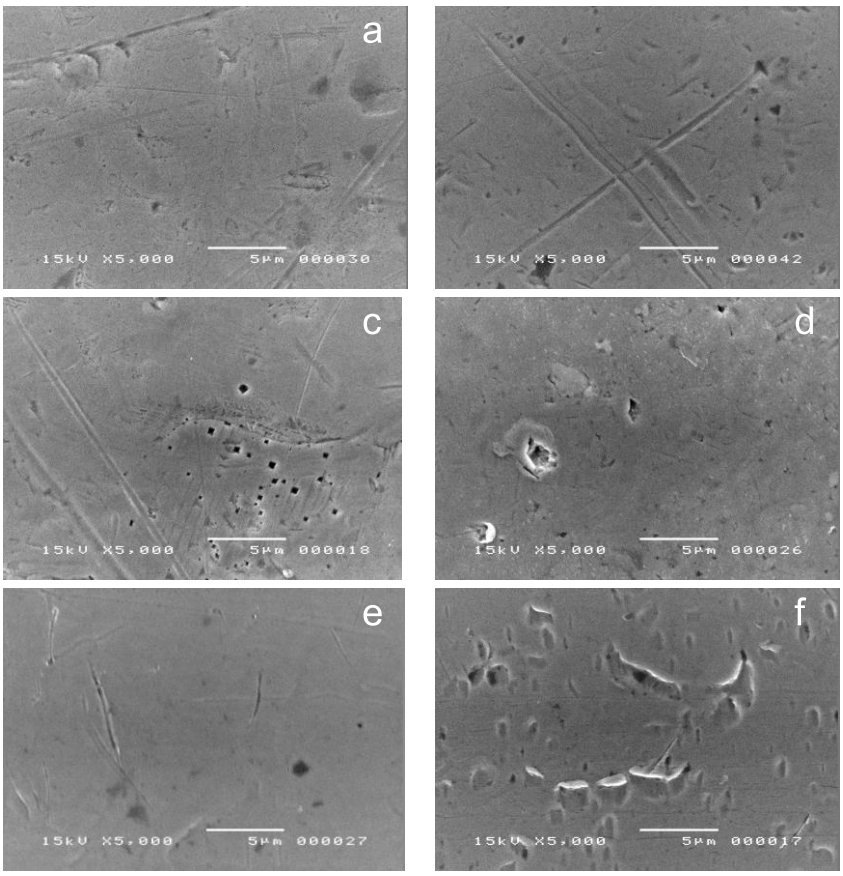

Figure 1. (a) Standard brackets before immersion at 5000x. (b) Fashion brackets before immersion at 5000x. (c) Standard brackets after immersion in artificial saliva (pH 3.75) at 5000x. (d) Fashion brackets after immersion in artificial saliva (pH 3.75) at 5000x. (e) Standard brackets after immersion in artificial saliva (pH 6.25) at 5000x. (f) Fashion brackets after immersion in artificial saliva (pH 6.25) at 5000x.

EDS

The results from EDS found that there are similar metal ions components on both groups. Standard brackets mainly contained Fe and Cr, which were 70.32% and 14.56% respectively while there were 3.40% of Ni and 0.87% of Cu. Also, fashion orthodontic brackets contained Fe in the highest percentage as 66.85%, followed by Cr as 15.48%, Ni as 3.83% and Cu as 0.41%. Furthermore, there were traces of Al, Cu, As and Pb but less than 1% in both groups (Table 1).

Table 1. EDS results before immersion

EDS (%) (Before immersion)	C	Cr	Fe	Ni	Cu	Al	Pb
Standardized brackets	9.88 ± 1.11	14.56 ± 0.42	70.33 ± 1.50	3.40 ± 0.20	0.87 ± 0.23	0.31 ± 0.1	0.06 ± 0.04
Fashion brackets	13.03 ± 4.55	15.48 ± 0.66	66.85 ± 3.46	3.83 ± 0.40	0.41 ± 0.13	0.17 ± 0.02	0.10 ± 0.04

ICP-OES

After immersion in artificial saliva at pH 6.25 for 28 days, ions release from standard orthodontic brackets showed average values as 216.87 µg/L of Ni while Cr, Cu and Fe ions could not detected. From fashion brackets the mean ions releases were 4808.83 µg/L of Ni and 21.24 µg/L of Cu whereas Cr and Fe ions could not detected (Figure 2, 3, 4, 5)

At pH 3.75, the mean amount of Cr, Cu, Fe and Ni ion releases from standard orthodontic brackets were 9.19, 0, 131.83 and 35.42 µg/L, respectively. On the other hand, the average level Cr, Cu, Fe and Ni ion releases from fashion brackets were 80.65, 127.70, 538.75 and 51751.67 µg/L (Figure 2, 3, 4, 5)

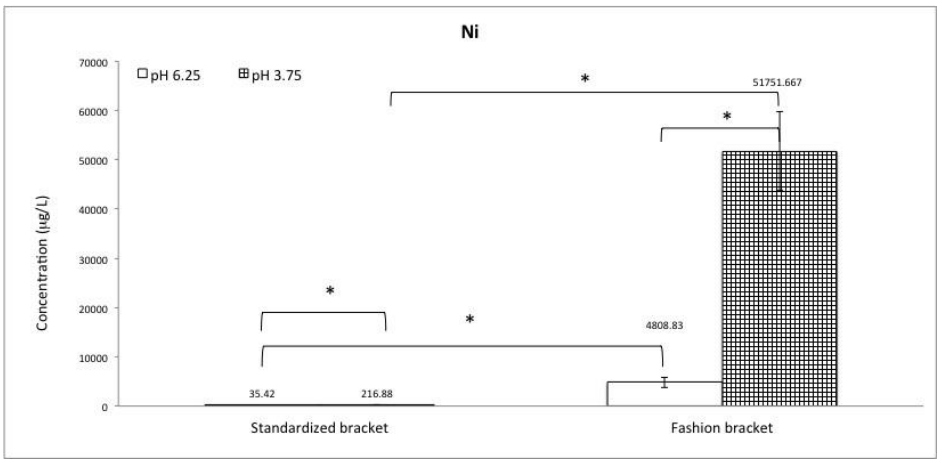

Figure 2. Concentrations of nickel ion (µg/L) release from standardized and fashioned brackets after immersion in artificial saliva at pH 6.25 and pH 3.75 for 28 days. *Significant difference compared between specimens in different pH and between standardized and fashioned samples; $p<0.05$, n=6

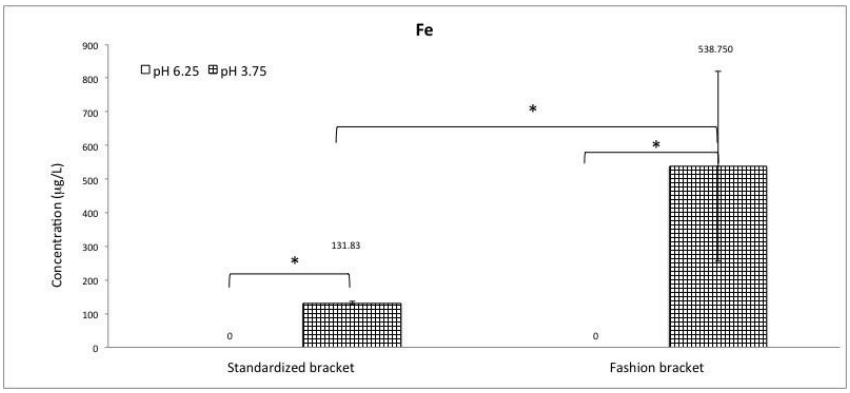

Figure 3. Concentrations of iron ion (µg/L) release from standardized and fashioned brackets after immersion in artificial saliva at pH 6.25 and pH 3.75 for 28 days. *Significant difference compared between specimens in different pH and between standardized and fashioned samples; $p<0.05$, n=6

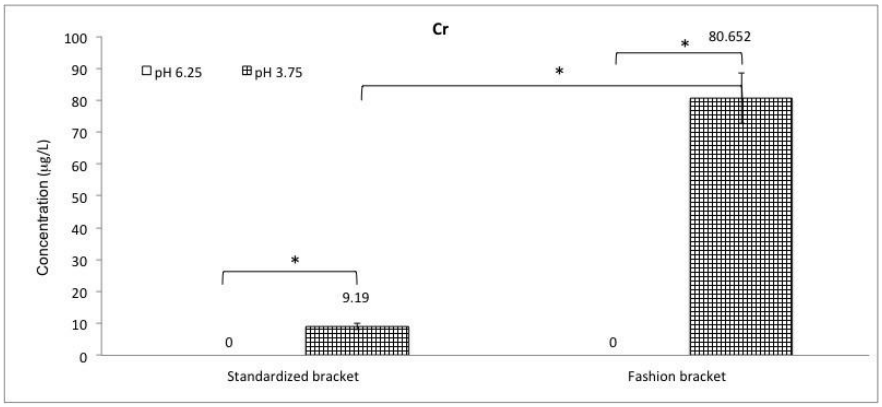

Figure 4. Concentrations of chromium ion (µg/L) release from standardized and fashioned brackets after immersion in artificial saliva at pH 6.25 and pH 3.75 for 28 days. *Significant difference compared between specimens in different pH and between standardized and fashioned samples; $p<0.05$, n=6

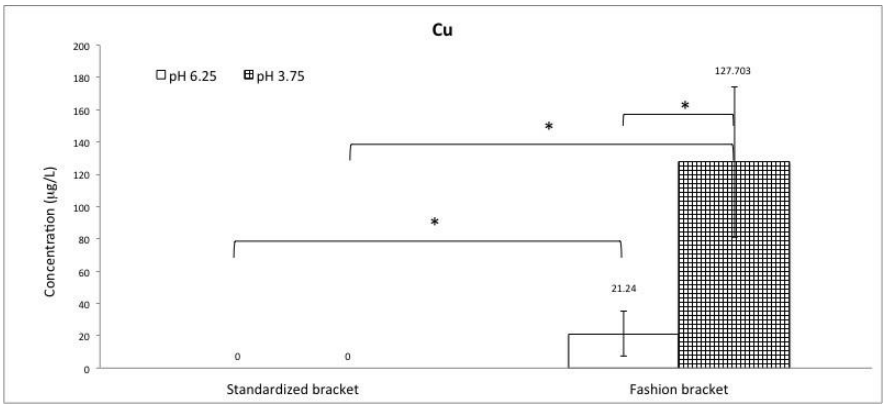

Figure 5. Concentrations of copper ion (µg/L) release from standardized and fashioned brackets after immersion in artificial saliva at pH 6.25 and pH 3.75 for 28 days. *Significant difference compared between specimens in different pH and between standardized and fashioned samples; $p<0.05$, n=6

The results of SEM showed variations of surface morphology before and after immersion in both standardized brackets and fashion brackets. According to Eliades et al (2003), corrosion in the form of pitting can occur in brackets and wires. A pit is considered as a pore with a depth equal to its width. Interestingly, initiation of the process may take place before intraoral placement since excessively porous surfaces were found on as-received product.

Before immersion test, there were 5 elements detected by using EDS in both standardized brackets and fashion brackets. Those 5 elements were Iron (Fe), Chromium (Cr), Carbon (C), Nickel (Ni), and Copper (Cu). After 28 days of immersion in both pH values, all results showed no particular difference in surface analysis. There were minor amounts of Carbon and Oxygen detect from EDS. In addition, Fe and Cr always shown to be main elements in orthodontic brackets, similar to as recent studies (Shintcovsk et al, 2015; Zenelis et al, 2004).

Pseudo-orthodontics wires distributed around Bangkok area were composed of hazardous composition, such Cd, Pb and As (Rityoue and Sasawongsaroj, 2009). However, the evidence of metal ions released from fashion brackets had never been reported. On the other hand, from EDS results in this study, these hazardous compositions could not be detected from fashion brackets.

From ICP-EOS, the results showed significant differences in all values between fashion and standardized brackets in pH 3.75. Especially, fashion brackets showed dramatically differences of Ni ion release in pH 3.75 and pH 6.25 were 51,751.67 µg/L and 4,808.833 µg/L, respectively. Both values were over the critical values of Ni for causing allergic reactions (600-2500µg/L), and the daily dietary intake (300-600 µg/L) (Kaaber et al, 1978; Schroeder et al, 1962). The ratio of Ni-ions release at pH 6.25 between standard and fashion brackets was 1:135.76, and that of Cu ion was 1:21.24. In addition, at pH 3.75, Ni, Cu, Fe and Cr showed the ratio of 1:238.61, 1:127.70, 1:4.08 and 1:8.77, respectively. The results also showed increases in ions release as the pH decrease, similar to the study from Staffolani et al (1999). The result showed that Ni release of fashion brackets in both pH were dratisically higher than standardized brackets. It could be explained that the maufacturing process might be different and affected to metallurgical qualities.

In pH 3.75, the amount of releasing ions were higher than in pH 6.25 except Cu ion in standardized brackets that was not detected in both pH. Similarly to the recent reports, the pH value of artificial saliva influenced the number of ions released (Kuhta et al, 2009; Huang et at, 2003, 2004).

Many researchers observed allergic reactions associated with the use of metals. An example was a case of cutaneous hypersensitivity on metal contact to oral mucosa. A condition, which could be seriously developed in-patient with history of allergy (Genelhu et al, 2005; Schultz and Connelly, 2004). Nickel also caused allergic gingivitis (Ramadan, 2004), DNA damage in oral mucosa cells and inhibition of DNA synthesis (Faccioni et al, 2003).

Other factors regarding fashion orthodontics that could be considered hostile were not considered. Such things like bonding agents or elastomeric rings would also be required further studies. Further investigation regarding cytotoxicity from fashion orthodontic is also considered plausible (Vande et al, 2007).

CONCLUSION

This study confirms the hypothesis that significantly higher level of metal ions was released from fashion orthodontic appliances than that from standardized orthodontic

appliances. Especially, the Ni ion released was over the critical values and daily dietary intakes which caused allergic reaction and DNA damages

ACKNOWLEDGMENT

This study was granted by Research Institute of Rangsit University.

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