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COMPARISON OF RELEASING NICKEL FROM THE UNTOUCHED, TRIMMED AND OPEN FACE DENTAL CROWNS (EXPERIMENTAL STUDY)

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ABSTRACT

Background and objective: Stainless steel crowns is the most effective and durable restoration for Primary molar tooth under treatment. Being allergic to Nickel, as one of the main elements in these crowns, is prevalent. The aim of this study was to investigate the release of Nickel in three trademarks existing in Iran and assess the trimming effect and making crowns open face.
Methods and Materials: this experimental study was done on 18 crowns in three groups as A: 3M , B: MIB and C: DNTO which every group includes three subgroups of intact, trimmed and open face floating in 5 ml of artificial saliva.
The level of released Nickel from 18 crowns of three trademarks with three different modes was evaluated within two times (one day and seven days) by Atomic absorption spectrophotometry. In order to analyze the data, SPSS20 was used.
To test the hypotheses of this study, Descriptive and inferential statistical tests such as Mean comparison, Factorial analysis of variance and correlation coefficient were used. The results with 95% confidence level were reported.
Results: The concentration of released Nickel reduced from the first day to the seventh day, respectively ($P<0.05$) and the reduction rate in three groups was significant. The concentration of released Nickel from three different trademarks was not significant, in comparison to one another. The concentration of released Nickel from three different modes was not significant, in comparison to one another.
Conclusion: Different trademarks and different modes of crowns do not effect on releasing Nickel but they are effective on the level of releasing.

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Introduction

Stainless steel crown (SSC) is considered as one of the most widely used methods of restoration in deciduous teeth which in accordance with some principles and proceedings of preparation, it is adapted to teeth and then cemented (1). The chemical compounds of SSC include 65-70% iron, 17-20% Chromium and 8-13% Nickel and less than 2% Manganese, Silicon and carbon. A little amount of metals in SSC can be released inside of the oral cavity and this metal leak can bring in allergic response potentially (2).

Nickel is recognized as one of the reasons of allergy (3) and about 10% of people are allergic to it (4). According to the reports, 5,4-5 and 28% of people are allergic to Nickel (5). Also, it is defined as Carcinogenic and Mutagenic factor (5-9). In addition to these clinical symptoms like allergic dermatitis, Asthma, Mucosal ulcers and Cellular toxicity and a change in cellular

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function are attributed to this metal (10). From the symptoms of oral contact allergy of Nickel used in dentistry, we can point out Lichen planus, stomatitis, severe inflammatory hyperplasia around the crowns containing nickel, relevant alveolar bone loss, and edema of throat, palate and gums (11-14).

Intraoral contact dermatitis appears as Lichenoid plaques in buccal mucus adjacent to allergens- which may be Ortho appliance or SSC. However, in a study, a case allergic to Nickel in an 11-year old child with oral symptoms and inflation of lips and also skin rash on the stomach was reported (15). A long term exposure to materials containing Nickel in dentistry may damage Monocytes, Oral mucosal cells, also DNS and cultured cells (16-19).

Different studies about releasing the metal ions had different results. Some of them suggested increasing concentration of metal ions in oral liquids of patients with Ortho appliance (20-23). On the other hand, other studies did not suggest any difference in concentration of metal ions between the samples with Ortho appliance and the samples lacking it (24). Keinan et al. evaluated the absorption of released metal ions from SSC by the root of laminated primary molar teeth. They found that crowns release Nickel in oral environment and these ions are absorbed by the root of primary molar teeth (25). Bhaskar et al. found that the amount of released Nickel maximized at highest level in the seventh day after placing spacer, but this amount could not cause Toxicity (26). Zenelis et al, suggested that there is not any significant difference between the metal compounds of used crowns and non-used crowns (27). Ramezani et al. reported that the amount of Nickel measured from the crowns is less than toxic level (28).

It seems that trimming can effect on the level of Nick release and it is possible to extend it to the critical limit. With regard to the widespread use of SSC in Pediatric Dentistry and the potential effects of released metals, this study investigated and compared the amount of nickel release from different trademarks of SSC, trimming effect and reducing the cross section of metal in artificial saliva.

This in vitro study, 18 Stainless steel crown from three trademarks including 3M (3M/ESPE, USA), MIB (MIB/ IdeBartar Co., France) and DNTO (DENTO/ Kaohsiung, Taiwan) were used. All the crowns were selected from the right side of the upper jaw with size of D5 (6 crowns from each mark). Based on the format of study and considering three different trademarks and modes, the crowns were classified and named in three groups and 9 subgroups.

Group A (3M): includes 6 SSC examined in untouched subgroups (2 SSC), trimmed (2 SSC) and open face (2 SSC).

Group B (MIB): includes 6 SSC examined in untouched subgroups (2 SSC), trimmed (2 SSC) and open face (2 SSC).

Group C (DNTO): includes 6 SSC examined in untouched subgroups (2 SSC), trimmed (2 SSC) and open face (2 SSC).

In order to calculate the amount of Nickel released from crowns accurately, two samples in each group were evaluated separately and then mean was indicated.

The rate of releasing Nickel was measured in two steps following 24 hours and one week.

Before starting the study, in order to be certain of the digit read from Furnance Atomic Absorption Spectrophotometer Analytic jena,AAS5EA,(Germany), three samples of crown were investigated as a pilot in the artificial saliva (Hypozalix;biocodex,France) with normal temperature of 37º C. However, the results received from the analysis of these three samples were not included in the main samples. For trimming the samples of trim subgroups, a line by 1mm distance was drawn from the edge of crowns. Then by special scissors (MIB/IdeBartar Co.,France), the crowns were shortened and the trimmed edges became flat and smooth by pink molt and white polish rubber (Tizkavan,Iran).

In order to prevent cement from sticking to the external walls of crown, the outer surface was smeared with Vaseline. The inner surface of selected crowns was filled by a pure alcohol and Glass ionomer cement (GC Fuji, Tokyo, Japan) and then cement was set after some times.

In open face group, after setting the cement, a window by dimension of 3 to 5 ml was made by drill and the edges became flat and smooth by polish rubber. Vaseline on the samples was removed by alcohol.

Each crown was placed in a separate dish. Then, 5ml of artificial saliva was poured on it so that the crowns were floating in the artificial saliva.

The artificial saliva used in this study has the following formula: Potassium chloride 62 mg in 100 ml of sodium chloride 86 mg in 100 ml, magnesium chloride 5 mg in 100 ml, calcium chloride 16 mg in 100 ml, Di-Potassium Phosphate 80 mg in 100 ml, monopotassium phosphate 32 mg 100 milliliter .

Eighteen containers containing samples were placed in an incubator (Memert;INB500,E60529-IP20 Schutzart,Germany) regulated at 37º C (as a normal temperature of oral cavity). After passing 1 day, the amount of Nickel in artificial saliva related to each sample was measured. These measurements were done by Atomic absorption spectrophotometry and the results were reported as ppb (Part Per Billion). As it was likely that the basic composition of saliva change due to some reasons, the fresh saliva was used for keeping the test and following the seventh day, all the samples were measured and analyzed likewise.

Statistical Analysis

In order to analyze the data, SPSS 20 was used. To test the hypotheses of this study, Descriptive and inferential statistical tests such as Mean comparison, Factorial analysis of variance and correlation coefficient were used. The results with 95% confidence level were reported.

Results

The mean of released Nickel received from three groups during the test (1^{st} and 7^{th} days) was 0.444 ppb. There was a significant difference between the measured amount of metal during the interval of 1^{st} and 7^{th} day ($P<0.05$) resulting that Nickel release

in 1st day was higher than the 7th day. The highest level of released Nickel was related to MIB crowns and the lowest level was related to 3M ones, but there was not any significant difference among three different trademarks.
The concentration of released Nickel from three trademarks of SSC in artificial saliva reduced from the 1st to 7th day significantly (P<0.05). This level of reduction in MIB was more than that in other groups (Table 1).
There was not a significant difference between the levels of Nickel release during the 1st and 7th day in different trademarks. Nickel release was at its highest and lowest level in MIB and 3M crowns, respectively (table 2).
Although there was not a significant difference between the levels of Nickel release in different modes of Nickel, the highest and the lowest level of Nickel release was related to Open face and trim subgroups, respectively (table 3).
Comparison of the levels of Nickel release from different crown modes did not show any significant difference. However in 3M group, intact subgroups and open face group, the level of Nickel release was less than trim group. In MIB group, Open face subgroups and intact subgroup had the highest and lowest level of release, respectively. In DNTO group, the intact subgroup and trim subgroup had the highest and the lowest level of release, respectively.

Table 1. The mean of Nickel release in crowns with regard to time variable and trademarks

Trademark	Time	Mean	P value
3M	1 day	0.370	0.000
	7 days	0.033	
MIB	1 day	1.179	0.026
	7 days	0.000	
DNTO	1 day	1.081	0.000
	7 days	0.003	

T test

Table 2. Comparing the difference of Nickel release with different trademarks (in 1st and 7th day)

Trademark	Trademark	Mean df	P value
3M	MIB	-0.388	0.140
	DNTO	-0.341	0.192
MIB	3M	0.388	0.140
	DNTO	0.047	0.855
DNTO	3M	0.341	0.192
	MIB	-0.047	0.855

LSD test

Table 3. Comparing the difference of Nickel release with different modes of crown (sum of 1st and 7th day)

Crown mode	Crown mode	Mean df	P value
Intact	Trimmed	0.048	0.852
	Open face	-0.243	0.349
Trimmed	Intact	-0.48	0.852
	Open face	-0.291	0.264
Open face	Intact	0.243	0.349
	Trimmed	0.291	0.264

Discussion

SSCs are applied as a durable restorative method in Pediatric Dentistry. In spite of advantages of SSCs, there are some disadvantages such as: Periodontal problems, considerations relating to beauty and secondary reactions related to ions release (29).
Today, there are many developments in compounds and quality of alloys used in oral appliances and their Biocompatibility and durability in oral environment has been increasingly improved. However, some cases of allergy increase and toxic reactions relating to this issue has been reported (30).
There are a few studies about assessing the relationship between being allergic to Nickel and SSC. Many studies investigated this relationship in orthodontic appliances. Feasby et al, found that in children who have oral appliances containing Nickel, it is highly likely that the allergy test (patch test) be positive (31).
According to the previous and present study, the amount of Nickel released from a crown in laboratory condition or in oral environment is not critical but what is thinkable is that whether placing several crowns in the mouth of child at the same time or simultaneous presence of orthodontic appliances, crown and spacer causes Nickel release exceeding from critical limit (32).

Different studies suggested that the amount of Nickel released in the mouth was below the critical limit and its toxic effect is highly unlikely. However, long term presence of orthodontic appliances in the mouth could cause allergic reactions (5). Yilmaz reported the symptoms of increasing allergy which occurred with only one SSC on the permanent primary molar tooth of child (2).

The reason of allergic reactions to a little Nickel can be attributed to the high capacity of haptens in released metal (5). Haptens are small molecules which cannot activate immunity system alone, but in case of formation of Hapten–Protein Conjugates, they can do it. In fact this compound has been converted to the antigens and resulted in forming the antibody of anti-heptane. This kind of antibodies can be specifically created as the same method for the metal ions like Nickel (28). Although the results of study by Setcos JC suggested that orthodontic appliances does not only relate to allergy increase but also this low exposure causes resistance to allergens (32).

With regard to the present study, Atomic absorption spectrophotometry recognized a lot of Nickel in saliva. Releasing Nickel from Ortho appliances has been suggested in many studies (6,33,21,34,35). Keinan (25) and Kodaira (16), Ramazani (28) and Jamilian (35) have reported the release of Nickel from steel stainless crowns which is consistent with the results of the present study.

Increasing the concentration of metal ion in artificial saliva is due to alloy corrosion. In fact, saliva is considered as a mediator for creating an Electrochemical cell and corrosion process of surface of metal crowns (11). The previous studies suggested that releasing metal from orthodontic appliances is related to combining wires (5). In this regard, releasing metal components from SSC in oral cavity does not effect on the concentration of these components inside of the crown (25).

From these findings, we can infer that although the crowns in oral environment release a little Nickel, this issue does not cause a change in primary compound of crown and as a result, the strength and other advantages relating to its elements.

The present study suggests that Nickel releasing occurs at its highest level during the initial steps (the first day) (Table 1). This result was consistent with the study of Ramazani (18) that suggested the highest amount of concentration in the first day and Maja Kuhta (5) that suggested the highest amount of concentration during the first 7 days, but Bhaskar reported the highest amount of concentration at the end of the seventh day. The reason of this difference may be related to the appliance used (SSC).

With regard to the time variable, it was reported that Nickel released from dental alloy can aggregate in cells over time and have many harmful effects (36). Suppressing the leukocyte chemotaxis and a change in synthesis of DNA and Enzymatic activity can be of those harmful effects (37, 38).

In this study, the highest amount of Nickel release in all the groups in the first day of floating was estimated to be ppb 444/0 (mg/ml 000444/0), which is not considerable in toxicity creation. This amount is much less than the amount of what Nickel receives daily (200-300 µg that is 0.2-0.3 ppm) (4, 26). Reducing the amount of concentration of Nickel over time can be the reason of forming the oxide layer on alloy and this layer protects the surface against corrosion and thus slows down the process of releasing metal ion (18, 39).

In each three trademarks, the amount of Nickel released from crowns reduces (PM0.05). This descending process in these trademarks was rather similar (Table 1). Thus, it can be concluded that clinically using, SSC does not effect on the amount of releasing Nickel over time. In other words, all the types of crowns used in this study released the highest amount of Nickel during the first days and then the amount of released Nickel reduces. In fact, if crown is supposed to have harmful effects on releasing metal ion, it happens during the first days. However, it was told that this short time includes in the same time frame of allergic reactions (40).

3M crowns and MIB crowns suggest the least and the most amount of Nickel releasing, respectively. Although, in the present study the amount of Nickel release was not significant in none of the groups and was less than the critical limit, we can suggest to use 3M crowns to stop the allergic reactions with that little amount.

In comparison of Nickel released from different modes of crowns, Open face crowns and trimmed crowns suggest the most and the least amount, respectively (Table 3). Based on these calculations, we can conclude that the concentration of released Nickel is effected by the area of crown surface rather than its edges. But to justify whether the open face crowns had the highest amount of released Nickel, it seems that making windows on the crown by drill not only disunites the structure of crown, but also increases the edges contact with saliva and finally the amount of Nickel.

Open face crowns are prescribed for the areas which beauty and strength are main factors. Regarding that in posterior teeth, beauty is not an important factor and also Occlusal forces in posterior teeth cause composite separate from the buccal surface of crown, this issue may bring in releasing Nickel (41).

In this study and the others, releasing the metal ion of Nickel from steel stainless appliances was shown. Although all the studies estimated the amount of Nickel released from a crown to be below the critical limit, and with regard to the cumulative effect of Nickel in cells and that some crowns are placed simultaneously in the mouth of patient and through the reports of existing cased allergic to SSC and TPA (2, 40), perhaps it's better to ask questions about being alleric to Nickel for girls in the primary examination of patient (40).

Conclusions

The amount of released Nickel on crowns of three trademarks was higher in the first day than 7th day. And this amount was significant in these three trademarks and there was not any significant difference among these marks.

1. The amount of released Nickel from open face crowns was higher than intact and trimmed crowns, but this amount was not significant.
2. The amount of released Nickel from trimmed crowns was less than intact and open face crowns, but this amount was not significant.
3. The amount of released Nickel from intact crowns was less than trimmed and open face crowns, but this amount was not significant.

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