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RESEARCH ARTICLE

An in-vitro evaluation of nickel and chromium release from labial and lingual brackets

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Abstract

Objective : To evaluate and compare the levels of nickel and chromium at 1,7 and 30 days after immersion of labial and lingual appliance systems in a simulated oral environment.
Materials and methods: The sample comprised 20 labial and lingual orthodontic brackets of upper premolars, 0.017 X 0.025 inch stainless steel arch wires and band material 0.05 inch stainless steel. The components of each group were placed in a separate polypropylene tube containing 50 ml of synthetic or artificial saliva solution. The solutions inside each tube at each experimental period were analyzed by spectrometry to determine Ni and Cr content.
Results: The release of nickel and chromium from labial and lingual brackets progressively increased from day 1 to 7 and then decreased at day 30.
Conclusion: The amount of Ni and Cr released in the study is negligible and it is far below the levels known to induce cell damage.

INTRODUCTION

Stainless steel alloys containing 8% to 12% nickel and 17% to 22% chromium are generally used in orthodontic appliances.[1]

Nickel is added to stabilize the austenitic phase, improve the anti-corrosive property of the alloy and decrease the ductility whilst chromium is added to facilitate the formation of an anti -corrosive passive film.[2]

The adverse effects of nickel inflicts have been widely documented suggesting that it is responsible for allergic reactions (more severe than those induced by other elements) and toxic interactions. Some studies have found nickel as a possible carcinogenic element while others have failed to determine carcinogenic effects derived from it.[3,4,5]

Although in orthodontics nickel represents the main concern as long as toxicity and allergy is concerned, other ions released from appliances also have toxic effects. Evidence shows that metal ions like nickel released during orthodontic treatment are far below the levels acquired by ingestion from a routine daily diet.[6]

In the late 1970s and beginning of the 1980s, Dr. Craven Kurz et al and Kinya Fujita introduced lingual orthodontics as a new technique for treating malocclusions. Lingual orthodontics is sometimes referred to as invisible orthodontics.[7,8,9] The main characteristic of this technique is the fact of bonding the brackets on the lingual and palatal surfaces rendering the appliance invisible. This technique has very much evolved.

A comparison of nickel and chromium release of labial and lingual brackets in a simulated oral environment has not been studied in vitro till date.

Hence the aim of our study was to evaluate and compare the levels of nickel and chromium at 1,7 and 30 days after immersion of labial and lingual appliance systems in a simulated oral environment.

Materials and methods

All the materials were procured from (Ormco Corp., Glendora, CA, USA). All the materials were used in as received state.

The sample comprised 20 labial and lingual orthodontic brackets of upper premolars, 0.017 X 0.025 inch stainless steel arch wires and band material 0.05 inch stainless steel.
The brackets were divided into two groups of ten each.
In **Group 1** (Labial) 10 brackets (**Mini 2000 brackets**, Ormco Corp, Glendora, CA, USA) were used.
In **Group 2** (Lingual) 10 brackets (**STB™ Light Lingual System**, Ormco Corp, Glendora, CA, USA) were used.
Along with the brackets, band material 5 cm long, 5cm length of 0.017 x 0.025 inch stainless steel arch wire was included for the study in both the groups. The band material and arch wires were cut with sterile pliers.[10]
The components of each group were placed in a separate polypropylene tube **(Tarson India Ltd, New Delhi)** containing 50 ml of synthetic or artificial saliva solution. The simulated saliva medium was synthesized on the basis of the formula given by Sali Lube Sinphar Pharm, Taipei, Taiwan.[11] According to this formula salts were measured on an electronic balance and mixed thoroughly in distilled water.
PROPORTION OF SALTS TO PREPARE 1L OF ARTIFICIAL SALIVA.[11]

Compound	Amount (mg)
Sodium chloride	0.844
Potassium chloride	1.2
Calcium chloride anhydrous	0.146
Magnesium chloride.6H20	0.052
Potassium phosphate dibasic	0.34
Sorbitol solution 70%	60 ml
Hydroxyethyl cellulose.	3.5

The components of each group were immersed in artificial saliva solution at 37°C for 30 days. The container was closed to prevent evaporation of the solution. After 1 day ± 1 h, brackets along with the band material and arch wire were removed from each tube and placed in other tubes with fresh immersion solution. This procedure was repeated at 7 and 30 days.
The solutions inside each tube at each experimental period were analyzed by spectrometry to determine Ni and Cr content. The sample was stored at -80º C in deep freezer. (ULT freezer, Thermo Electron Corporation, USA). Nickel and chromium estimation was done as suggested by Singh et al.[12]
In brief, processing was done by using 0.5 ml of saliva which was transferred to a 2ml plastic test tube by using a micropipette. The saliva samples were centrifuged at 3,000 rpm (Eppendorf Refrigerated Centrifuge) for 5 minutes to settle particulate matter.
The chemical analyses for nickel and chromium were performed by Atomic Absorption Spectrometer attached to a graphite furnace (Perkin Elmer, HGA 900, Germany). The technique makes use of the wavelengths of light specifically absorbed by an element. Standard calibration curves were made for nickel and chromium using several solutions of known concentrations (20 to 100 ppm).
20 μL of the sample was injected directly into the graphite tube from an automated micropipette and sample exchanger. The tube was heated electrically by passing a current of 5mA through it in a programmed series of steps that include 15 seconds at 120º C to evaporate the solvent, 6 seconds at 950º C to drive off any volatile organic material and char the sample to ash and 5 seconds at 2,100º C to vaporize and atomize the elements. Heating the tube to 2,300º C made it ready for the next sample.
A beam of electromagnetic radiation from a hollow cathode lamp specific for nickel (232 nm) and chromium (357.9 nm) was passed through the vaporized sample using argon gas. The metal atoms in the sample absorb some of the irradiation. This gave the absorbance of the sample, which enabled the estimation of the nickel and chromium concentration in the unknown sample from the standard calibration curves.
The concentrations of nickel and chromium were expressed in micrograms per liter (μg/L). Each sample was analyzed in triplicates and the mean value was calculated.

Results

A large variation in the concentrations of both nickel and chromium was observed in both the groups as seen in table I and table II.

Table I

MEAN VALUES OF NICKEL IN µG/L FOR GROUP 1 (LABIAL) AND GROUP 2 (LINGUAL)

TIME	GROUP 1 (µG/L)	GROUP 2 (µG/L)
1 day after placement	1.45 ± 0.57	2.32 ± 0.30
7 days after placement	2.19 ± 1.68	3.95 ± 2.11
30 days after placement	1.48 ± 1.03	1.62 ± 1.79

Table II

MEAN VALUES OF CHROMIUM IN µG/L FOR GROUP 1 (LABIAL) AND GROUP 2 (LINGUAL)

TIME	GROUP 1 (µG/L)	GROUP 2 (µG/L)
1 day after placement	2.78 ± 2.09	2.65 ± 2.71
7 days after placement	3.49 ± 1.16	3.34 ± 1.19
30 days after placement	2.98 ± 1.31	2.81 ± 1.16

The release of nickel and chromium from labial and lingual brackets progressively increased from day 1 to7 and then decreased at day 30 as illustrated in fig I, II, III, IV.

FIGURE I:

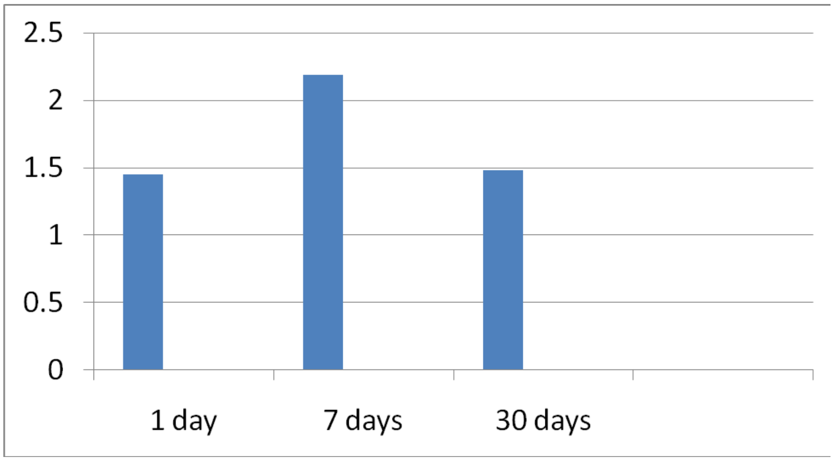

Figure 1: Release of nickel in µg/L from labial brackets.

FIGURE II:

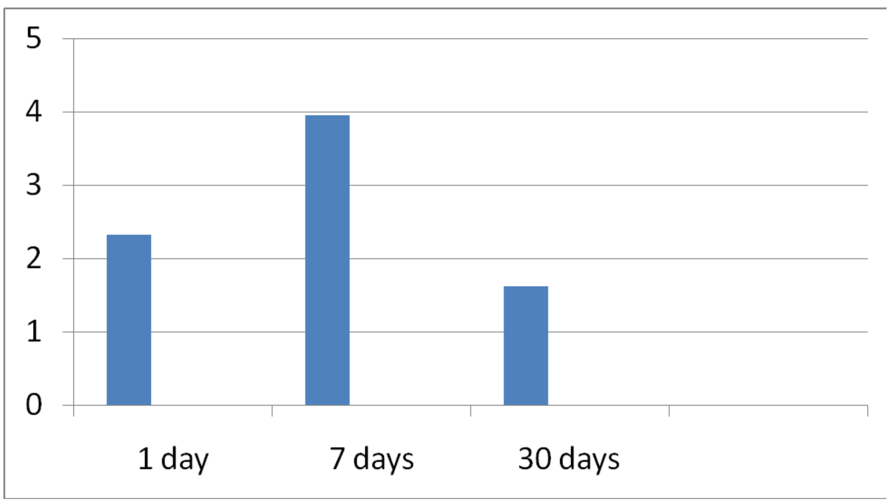

Figure 2: Release of nickel in µg/L from lingual brackets

FIGURE III

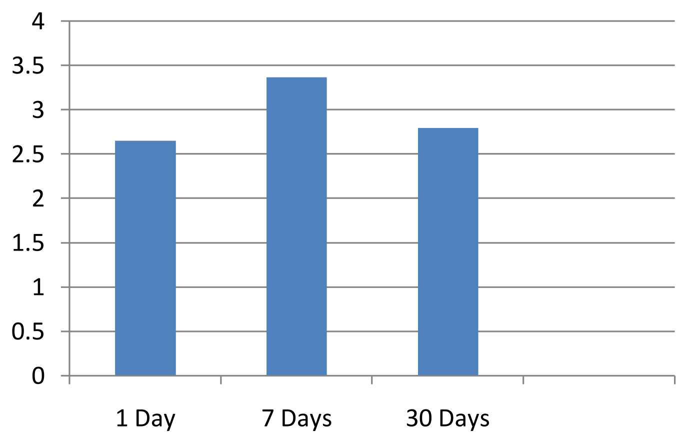

Figure 3: Release of chromium in µg/L from labial brackets

FIGURE IV

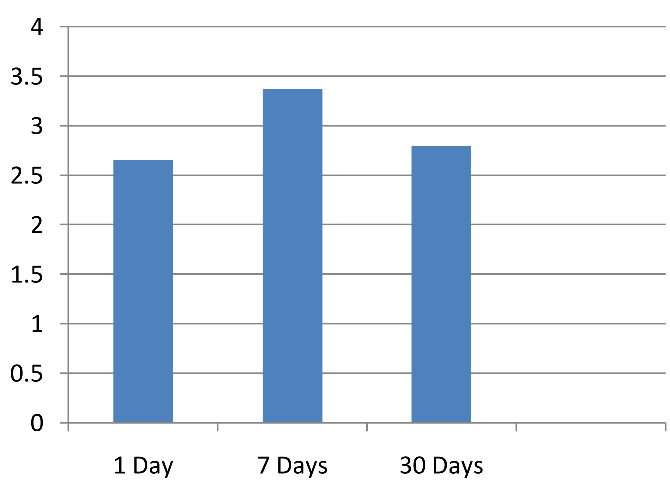

Figure 4: Release of chromium in µg/L from lingual brackets

There was greater release of nickel from the lingual bracket when compared with the labial brackets as given in fig V, whereas the chromium release was less for the lingual group as shown in fig VI.

FIGURE V :

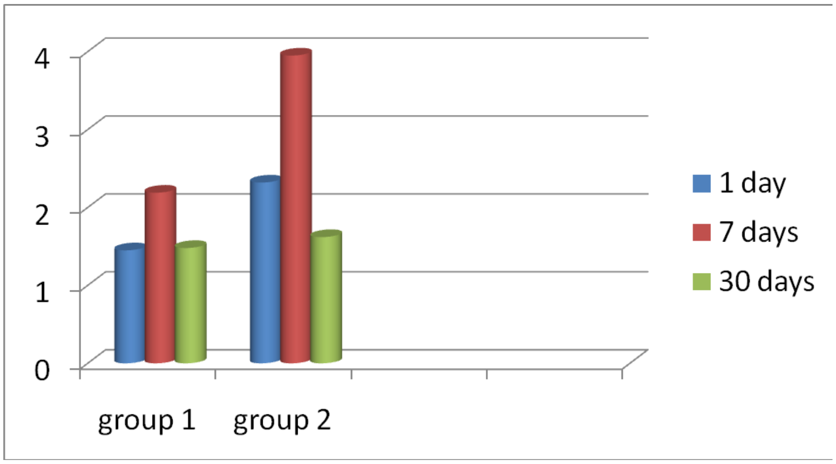

Figure 5: Comparison of nickel values in between group1 and group 2

FIGURE VI:

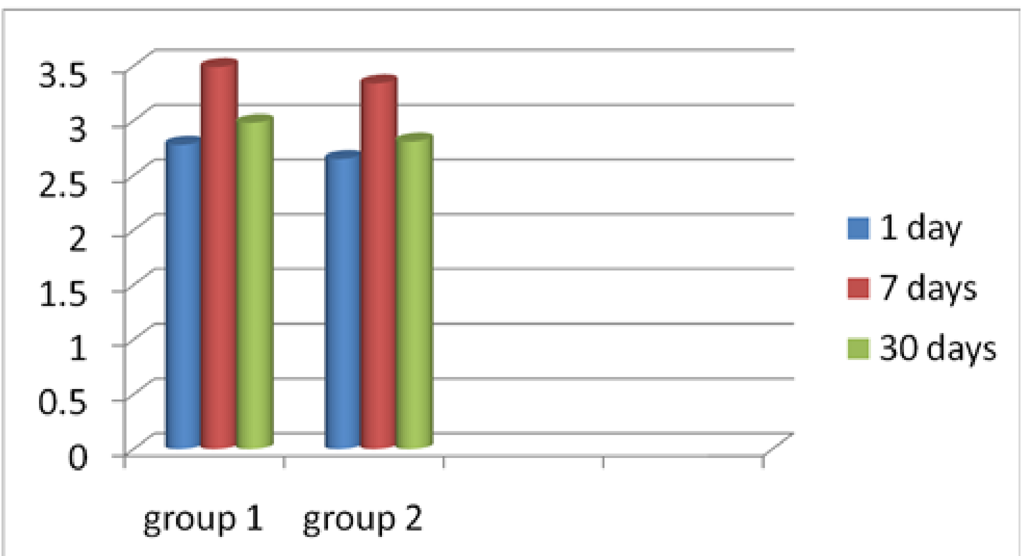

Figure 6: Comparison of chromium values between group 1 and group 2

Discussion

The release of metal ions from dental alloys 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 degradation.[13] Nickel and chromium are two metals which are often used in the construction of various parts of orthodontic appliances. There are several variables which affect corrosion of nickel and chromium such as pH, temperature, oral flora and stress.[9]

Arch wire and band material standardization was done for both the groups. 0.017 X 0.025 inch stainless steel arch wires and band material 0.05 inch stainless steel was used in both the groups. So, it is more likely that the variation in nickel and chromium release from both the groups was because of the brackets.

This in vitro study emphasizes the importance of factors that can influence the release of metal ions from fixed orthodontic appliances (labial / lingual), namely, the type of alloy, the artificial saliva and time of exposure to the solution influenced ion release.

Two values are of use in order to put the results of Ni released in context and see the impact that they may have on patients. The first value is that stated by the regulation of the European Union concerning Ni release by utensils and jewellery items. This value is set at 0.5 lg/cm^2 of material surface per week for at least two years (0.714 ng/mm^2 on a daily basis).[15] The second value is the concentration known to impair the chemotaxis of leucocytes and stimulate neutrophils to become aspherical and move slowly (2500 ng/l or ppb).[16] The amount of Ni released is far below the daily limits established by the European Union[15]as seen in Table I.

Significant differences in nickel and chromium release in both the groups was observed between day 1 and 7. The release of nickel and chromium into artificial saliva from labial and lingual brackets progressively increased from day 1 to 7 and then decreased at day 30. This was similar to the results reported by Park and Shearer[17] who reported that the nickel and chromium release reached a plateau after 6 days.

Barrett et al[18] in an in vitro study found that nickel release reached a maximum after 1 week and then diminished while chromium increased in the first two weeks and then tapered in the next two weeks. Gjerdet et al[19] Kocadereli et al[20] and Staffolini et al[21] indentified increased metal levels immediately after bonding but no differences after three weeks. The highest amount of Ni release seen in this study is not even 1/10 of the amount of Ni required to inflict cell damage as found in other studies.[16]

Two explanations for the increased levels seen after 7 days and the decrease at day 30 have been provided by Barrett et al.[18] First, the nickel present on the surface of the stainless steel may quickly corrode during the first seven days of the experiment and then the rate of release drops off as the surface nickel is depleted. Second, corrosion products may have formed on the surface after 7 days slowing the corrosion of nickel. In the present study, the rate of chromium release also decreased after day 7 and therefore it is likely that a buildup of corrosion products occurred at this time since such an occurrence would have made the concentrations of both metals decrease after day 7.

The nickel and chromium release observed in this study is insignificant when compared to the average nickel intake from daily amounts of food (200 to 300µg) and beverages (20µg/L) and that of chromium in daily food (5 to100 µg) and beverages (0.43µg/L). This conclusion of insignificance has been reported by Park and Shearer[17], Sfondrini et al [22] and Barrett et al[18].

Greater release of chromium compared to nickel was also observed. The magnitude of nickel and chromium release from both the groups in the present study was generally less than the values reported by Kerosuo et al[1] and Luft et al[23]. The difference can perhaps be attributed to the diet and the methodology of the various studies.

Release of nickel and chromium into artificial saliva from lingual brackets has not been studied in vitro till date. In our study nickel release from the lingual brackets were considerably more as compared with the labial brackets. Whereas the chromium release was less for the lingual group.

The present investigation studies brackets in a noncorrosive environment. The in vitro conditions that were created are not identical to conditions that can be found in vivo. Degradation of orthodontic materials has been studied using different laboratory set-ups [24,25,26] but accelerated corrosive experiments or experiments performed in a non-corrosive environment cannot reliably simulate the oral environment in any case.

The results obtained in the present study should therefore be interpreted with that in mind. This study helps to understand the baseline behaviour of these kind of brackets so that, in the future, experiments with corrosive set-ups can be carried out, which may be closer to this in vivo situation.

Conclusion

The release of nickel and chromium into artificial saliva from labial and lingual brackets progressively increased from day 1 to day 7 and then decreased at day 30. There was greater release of nickel from the lingual bracket when compared with the labial brackets, whereas the chromium release was less for the lingual group.

More research should be carried out for a longer period of time to study the effect of corrosion processes and mechanical phenomena such as wear and fatigue on the release of nickel and chromium in the oral cavity. The amount of Ni and Cr release in the study is negligible and it is far below the levels known to induce cell damage. Moreover, nickel hypersensitivity should be observed on a long term basis, because symptoms can develop several years later.

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