



Assessment of Changes in Nickel and Chromium Levels in the Gingival Crevicular Fluid during Fixed Orthodontic Treatment

¹Vinny Bhasin, ²Swati J Pustake, ³Viprat Joshi, ⁴Anil Tiwari, ⁵Meenakshi Bhasin, ⁶Ramandeep S Punia

ABSTRACT

Background: Various components of appliances used in fixed orthodontic treatment are fabricated from materials that are highly resistant in nature and have high strength and biocompatibility. Corrosion of materials occurs inside the oral cavity due to numerous environmental or oral factors that act on them. These factors include temperature, pH variation, salivary conditions, mechanical loads, microbiological and enzymatic activity, and various food components. Gingival crevicular fluid (GCF) is the material obtained from the gingival sulcus and might act as a potential source for various biomarkers in the orthodontic setup because inflammatory-induced response is directly related to orthodontic forces in GCF. In the light of above-mentioned data, we planned this study to assess and evaluate the changes occurring in nickel and chromium levels in the GCF during fixed orthodontic treatment.

Materials and methods: This study included assessment of 30 patients who underwent fixed orthodontic treatment. Three samples were taken from the GCF of the patients giving a total of 90 samples. The samples were collected at the following time intervals: At baseline (pretreatment time), 1 month after the start of orthodontic treatment, and at 6 months after the commencement of orthodontic treatment. Cellulose strips were used for isolation of the tooth region. For GCF collection, a standardized cellulose acetate absorbent strip was used. Placement of the strips was done in the sulcus for 60 seconds for the collection of

the samples. Refrigeration of the specimen bottles was done for a minimum of 7 days and was then sent to a laboratory where specimens were transferred for atomic absorption spectrophotometry. All the results were analyzed by Statistical Package for the Social Sciences software.

Results: At 1 month, the mean value of nickel and chromium in GCF was found to be 4.5 and 4.9 µg/gm of GCF respectively. While comparing the mean nickel levels between 1 and 6 months and between baseline and 6 months, significant results were obtained. Significant results were also obtained while comparing the mean values of chromium in GCF between baseline and 6 months and between 1 and 6 months. Gingival health index of the patients was found to be associated with increased inflammation with the progression of time of orthodontic treatment.

Conclusion: Levels of nickel and chromium might show considerable elevation in the GCF with time along with an increase in the severity of inflammation in the gingival health in patients undergoing fixed orthodontic treatment.

Clinical significance: Regular oral prophylaxis of the patients undergoing orthodontic treatment should be done to avoid toxicities caused by the release of nickel and chromium and for maintenance of good oral hygiene and oral health.

Keywords: Chromium, Nickel, Orthodontic treatment.

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INTRODUCTION

In the field of orthodontics, fabrication of various structural components of the fixed orthodontic appliances is done with various materials having specific physical and chemical properties. One of the most commonly used materials for such purposes is stainless steel. It is widely used for the construction of wires, brackets, and other auxiliaries due to its highly resistant nature, its high strength, and its biocompatibility.^{1,2} With time, various other

^{1,4}Department of Orthodontics and Dentofacial Orthopaedics Hitkarini Dental College, Jabalpur, Madhya Pradesh, India

²Department of Prosthodontics, Mahatma Gandhi Vidyamandir's Karmaveer Bhausahab Hiray Dental college and Hospital Nashik, Maharashtra, India

³Department of Forensic Sciences, University of Western Australia, Crawley WA 6009, Australia

⁵Department of Oral Medicine and Radiology, Hitkarini Dental College, Jabalpur, Madhya Pradesh, India

⁶Department of Oral Medicine and Radiology, Dasmesh Institute of Research and Dental Sciences, Faridkot, Punjab, India

Corresponding Author: Vinny Bhasin, Department of Orthodontics and Dentofacial Orthopaedics, Hitkarini Dental College & Hospital, Jabalpur, Madhya Pradesh, India, e-mail: vinny79@yahoo.com

materials have also been utilized in this field of dentistry for making orthodontic materials. These materials include other type of wires, such as nickel–titanium (NiTi), beta Ti, cobalt chromium, and Teflon polyethylene-coated wires.¹

Corrosion of these materials occurs inside the oral cavity due to numerous environmental or oral factors that act on them. These factors include temperature, pH variation, salivary conditions, mechanical loads, microbiological and enzymatic activity, and various food components. Appliances become weak due to the action of all these agents and start releasing Ni, chromium, and so on, into the oral cavity. Important role is played by Ni and chromium which come under the category of trace elements.^{3,4}

Gingival crevicular fluid comprises exudates that can be obtained from the gingival sulcus and is a potential source for harvesting various factors that are associated with periodontal changes that occur under the influence of orthodontic treatment. The GCF might act as a potential source for various biomarkers in the orthodontic setup because inflammatory-induced response is directly related to orthodontic forces in GCF.⁵ In the light of above-mentioned data, we planned this study to assess and evaluate the changes occurring in Ni and chromium levels in the GCF during fixed orthodontic treatment.

MATERIALS AND METHODS

This study was conducted in the Department of Orthodontics of the Dental Institution and included assessment of 30 patients who underwent fixed orthodontic treatment from June 2011 to July 2016. Three samples were taken from the GCF of the patients giving a total of 90 samples. The samples were collected at the following time intervals:

- At baseline (pretreatment time)
- One month after the starting of orthodontic treatment
- Six months after the commencement of orthodontic treatment.

Ethical approval was taken from the Institutional Ethical Committee, and written consent was obtained after explaining in detail the entire research protocol. Out of 30 patients, 15 were males and 15 were females. Inclusion criteria for this study included:

- Patients willing to be part of this study
- Patients without history of any systemic illness
- Patients with any known drug allergy
- Patients without any metal restorations in oral cavity
- Patients with negative history of previous orthodontic treatment
- Patients without a history of alcohol and smoking habit.

Only those patients in whom fixed orthodontic treatment of maxillary arch was started were included. Bonding of the stainless steel brackets was done using

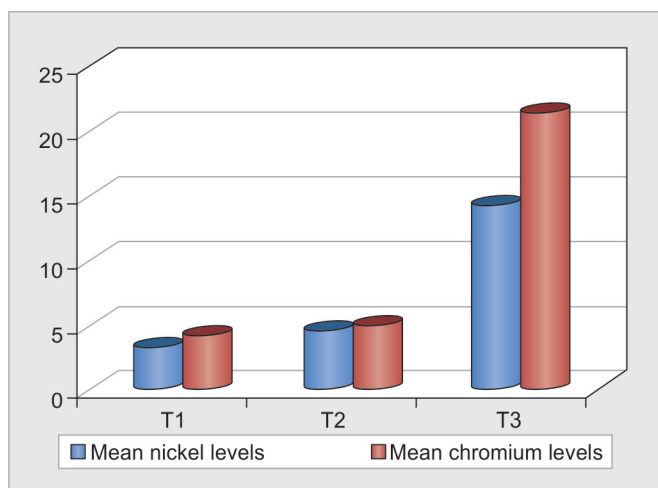
commercially available adhesive. Patients were given strict instructions on the oral hygiene maintenance before the commencement of the study. Patients were asked to brush twice daily during the time period of the study. Samples were collected from the patients during the morning session. Patients were instructed not to brush teeth on the day of sample collection. Patients were also instructed not to eat chromium- and Ni-rich food 48 hours before the collection of the samples. A senior and registered orthodontist and periodontist were employed to perform the sample collection procedure. Air drying of the teeth and the surrounding gingivae was done for eliminating the salivary contamination. Cellulose strips were used for isolation of the tooth region. For a collection of the GCF, a standardized cellulose acetate absorbent strip was used. Placement of the strips was done in the sulcus for 60 seconds for the collection of the samples. The GCF collection was done from a minimum of four sites in each patient and mean value was calculated. If bleeding occurred on sampling, sampling was immediately stopped, and another random site was chosen for collection of the sample. Placement of the PerioPaper strip was done in a glass container after successful finishing of the sampling procedure. Refrigeration of the specimen bottles was done for a minimum of 7 days and was then sent to a laboratory for further testing. Gingival health was assessed by evaluating the gingival index of Löe.⁶ This index categorized the gingival health into following types:

- 0: No inflammation
- 1: Mild inflammatory response, slight discoloration, slight edema, absence of ulceration, or continuous bleeding
- 2: Moderate inflammatory response, bleeding on probing
- 3: Severe inflammatory response, ulceration along with spontaneous bleeding.

In the laboratory, specimens were transferred for atomic absorption spectrophotometry. Twice examination of each specimen was done followed by a recording of the mean ion concentration in parts per million (mg/gm of GCF). All the results were analyzed by Statistical Package for the Social Sciences software. Chi-square test and Student's t-test were used for the assessment of the level of significance; $p < 0.05$ was taken as significant.

RESULTS

The mean values of Ni and chromium in GCF at baseline were 3.2 and 4.1 $\mu\text{g/gm}$ of GCF respectively (Graph 1). After 1 month, the mean value of Ni and chromium in GCF was found to be 4.5 and 4.9 $\mu\text{g/gm}$ of GCF respectively. When examined after 6 months, the mean level of Ni and chromium in GCF was observed to be 14.2 and



Graph 1: Mean values of nickel and chromium in GCF (µg/gm) at pretreatment (T1), 1 month (T2) and 6 months (T3)

21.4 µg/gm of GCF respectively. Comparative evaluation of mean Ni levels in GCF at various time intervals is shown in Table 1. While comparing the mean Ni levels between 1 and 6 months and between baseline and 6 months, significant results were obtained ($p < 0.05$) (Table 1). Table 2 shows the comparative evaluation of mean values of chromium in GCF between different time intervals. Significant results were obtained while comparing the mean values of chromium in GCF between baseline and 6 months and between 1 and 6 months ($p < 0.05$). Gingival health index of the patients was found to be associated with increased inflammation with progression of time of orthodontic treatment (Table 3).

DISCUSSION

Nickel and chromium are contained in variable amount in appliances used for fixed orthodontic treatment. The

composition of stainless steel appliances used in the construction of fixed orthodontic treatment includes chromium and Ni in 18 and 8% concentration respectively. Roughly 50% Ni is present in the orthodontic arch wires which are made up of NiTi.^{7,8} As a result of electrochemical breakdown, there is release of Ni and chromium in patients undergoing fixed orthodontic treatment, which may further have the potential to initiate “hypersensitivity” response.⁹

Nickel had particular importance in the recent past when studies highlighted its link with various pathological conditions. Specifically, chemotaxis of leukocytes along with stimulation of neutrophils to become aspherical was found to be impaired with Ni with amounts as low as 2.5 ng/mL (ppm).¹⁰⁻¹² Hence, we planned this study to assess and evaluate the changes occurring in Ni and chromium levels in the GCF during fixed orthodontic patients.

In this study, we observed that mean values of Ni and chromium in GCF were 3.2 and 4.1 µg/gm of GCF at baseline pretreatment time respectively (Graph 1). Significantly was observed while comparing the mean values of Ni and chromium in GCF when compared between baseline and 6 months ($p < 0.05$) (Tables 1 and 2). Our results were in correlation with the results obtained by Amini et al¹² who observed similar findings in their study. We also observed an increase in the severity of inflammation of the gingiva with time. Amini et al¹² also reported similar findings in their study where they observed fall in the health of gingival tissue with time in patients undergoing orthodontic treatment.

Amini et al¹² assessed the difference in levels of Ni and chromium in GCF in patients undergoing fixed orthodontic treatment. They measured the concentration of Ni and chromium before starting the treatment and

Table 1: Comparative evaluation of Nickel levels in GCF at different time intervals

Parameter	Different time intervals			p-value		
	Baseline	1 month	6 months	Baseline vs 1 month	1 vs 6 months	Baseline vs 6 months
Value in µg/gm of GCF	3.2	4.5	14.2	0.58	0.02*	0.01*

*Significant

Table 2: Comparative evaluation of Chromium levels in GCF at different time intervals

Parameter	Different time intervals			p-value		
	Baseline	1 month	6 months	Baseline vs 1 month	1 vs 6 months	Baseline vs 6 months
Value in µg/gm of GCF	4.1	4.9	21.4	0.69	0.03*	0.01*

*Significant

Table 3: Gingival health index of all the patients in this study

Time interval	Inflammation				Total subjects
	Normal	Mild	Moderate	Severe	
Baseline time	15	12	3	0	30
One month	0	12	18	0	30
Six months	0	8	18	4	30

at intervals of 1 and 6 months in 24 patients undergoing fixed orthodontic treatment among whom 12 were males and 12 were females with the help of atomic absorption spectrophotometry. They also calculated gingival index in all the sessions. They observed that gingival index over a period of time worsened significantly. In comparison to the baseline values, an increase of 150 and 510% was observed in the case of Ni in 1 and 6 months respectively. An increase in value of 200 and 700% was also observed in the case of chromium in 1 and 6 months respectively. From the results, the authors concluded that intensification of Ni and chromium levels might occur in the GCF during 6 months of fixed orthodontic treatment.

Amini et al¹³ assessed the hair Ni and chromium levels in 24 fixed orthodontic patients before and 6 months later. Mean age of the patients was found to be 18.38 years. They did not observe any significant difference in levels of Ni and chromium before and after the treatment. Amini et al¹⁴ assessed the impact of orthodontic treatment on salivary Ni and chromium levels. From 30 orthodontic patients, saliva samples were collected. All the patients were randomly divided into two study groups. One group consisted of patients with conventional brackets, and the other group consisted of patients with metal injection molding brackets. Twice collection of the samples was done. First sample was collected before the start of the treatment and second sample was collected 2 months later. Determination of the Ni and chromium levels was done using atomic absorption spectrophotometry. In both the groups, there was a significant increase in the mean Ni levels at pretreatment time and at 2 months time. From the above results, the authors concluded that in patients undergoing orthodontic treatment with both types of brackets, Ni levels might increase with time.

Singh et al¹⁵ evaluated the change in levels of salivary Ni and chromium concentration in patients undergoing fixed orthodontic treatment. They assessed 10 patients who had planned to undergo fixed orthodontic treatment; 17.5 years was the mean age of the subjects. All the salivary samples were collected thrice; at the pre-treatment time, after the first week of insertion of the orthodontic appliance, and finally at 3 weeks of insertion of the appliance. Atomic absorption spectrometer was used for assessment of Ni and chromium content. They observed a significant difference in salivary Ni and chromium concentrations at different time sessions in patients after insertion of fixed orthodontic appliances. From the results, the authors concluded that significant elevation in levels of salivary Ni and chromium concentrations occurs after insertion of fixed orthodontic appliances.

CONCLUSION

Considerable increase in the levels of Ni and chromium might occur in the GCF after 1 and 6 months of fixed orthodontic treatment. However, future studies are recommended in this field.

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