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# Studying the Corrosion Effect of Fixed Orthodontic Appliances on Thyroid Hormones

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**Abstract**

This study aimed to determine the nickel (Ni), and chromium (Cr) ions amounts and investigate their potential effects on thyroid hormones in patients' saliva who were receiving treatment with fixed orthodontic appliances (FOA). In this study, 42 FOA volunteers participated, and all samples were obtained from a specialized center for manufacturing and orthodontics in Bab Al-Moadham, Baghdad, Iraq. According to the findings, individuals with fixed orthodontics have significantly higher levels of the thyroid hormones ($P<0.05$) FT3 and FT4 than those who did not have orthodontic treatment, whereas there were no significant changes in TSH ($P=0.599$). Additionally, the amounts of $Ni^{+2}$ and $Cr^{+3}$ were considerably higher in the individuals receiving metallic orthodontic treatment ($P<0.0001$). The findings of this investigation support the hypothesis that corrosion metals from the FOA have a meaningful impact on the concentration of Ni and Cr ions and, consequently, on the thyroid and salivary functioning of the patient group.

**Keywords:** Nickel, Chromium, Fixed orthodontics, Thyroid hormones.

# تأثير تآكل أجهزة تقويم الأسنان الثابت على هرمونات الغدة الدرقية

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**الخلاصة**

الغرض من هذه الدراسة هو تحديد مستويات النيكل والكروم في لعاب المرضى الذين يخضعون لأجهزة تقويم الأسنان الثابتة العلاجية وتأثيراتها المحتملة على هرمونات الغدة الدرقية. اشتمل هذا البحث على 42 متطوعًا من مرضى تقويم الاسنان الثابت وجميع العينات تم جمعها من المركز التخصصي لصناعة وتقويم الأسنان في باب المعظم. تظهر هرمونات الغدة الدرقية زيادة معنوية ($P<0.05$) في هرمونات FT3 و FT4 في المرضى الذين يخضعون لتقويم الأسنان الثابت مقارنة بما قبل العلاج التقويمي ، بينما لا توجد فروق معنوية ($P=0.599$) في TSH. فضلا عن ذلك ، تراكيز Ni و Cr زادت بشكل كبير للمرضى الذين يخضعون لمجموعة علاج تقويم الأسنان المعدني ($P<0.0001$). يمكن الاستنتاج من نتائج هذه الدراسة أن هناك تأثيرًا حقيقيًا لمعادن التآكل من FOA على تركيز أيونات Ni و Cr مما يؤثرعلى وظائف اللعاب والغدة الدرقية لمجموعة المرضى.

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## 1.Introduction

Teeth can be precisely aligned with the help of orthodontic therapy, and the occlusal and jaw connections can be corrected [1]. The teeth can be adjusted straighter or positioned perfectly with orthodontic therapy. In addition to improving their appearance and ability to bite together, this can also make them easier to clean [2]. Like any other medical procedure, orthodontic therapy has benefits but also dangers and disadvantages. Orthodontics has a far lower risk of "doing harm" than other medical procedures, such as surgery [3].

Fixed orthodontic appliances (FOA) are frequently described as "non-compliance Class II correctors," which conveys a different idea about the amount of assistance needed during treatment [4]. Class II malocclusions are frequent and can be seen in a significant portion of individuals in need of orthodontic care [5]. A frequent therapeutic strategy, particularly for developing patients with Class II skeletal abnormalities who have convex profiles from retrognathic jaws, is functional orthopaedic therapy intended to promote mandibular development [6].

The majority of fixed orthodontic appliances, such as archwires and brackets, are made of stainless steel and nickel-titanium (Ni-Ti) alloys, which have the potential to corrode in the mouth [7]. The richest source of nickel among all alloys, nickel-titanium (Ni-Ti) alloys include 47 to 50% Ni and 45% Ti. The chromium in Ni-Ti also forms a thin, adherent passivating oxide layer that prevents oxygen from migrating into the alloy's underlying bulk and provides corrosion resistance [8]. Due to variable pressures (force), temperature fluctuations, a variety of meals, and electrochemical fluids, fixed orthodontic equipment are mostly constructed of metal that can release into saliva, which acts as a source for continual erosion over time [9]. The body's release of metal ions from FOA has been investigated under various circumstances [10]. Reduced salivary pH, a high-salt diet, soft drinks, fluoride-containing toothpaste, and mouthwashes are a few examples of things that might affect metal ion release [11].

Thyroxin (T4) is one of the thyroid hormones that represent 80 percent of the thyroid production. Thyroxin is also called tetraiodothyronine (T3) because it contains four iodine atoms [12]. Thyroxine (T4) and triiodothyronine (T3) secretion is primarily maintained by thyroxine stimulated hormones (TSH), which is secreted from the anterior pituitary gland [13]. Researchers have shown that nickel can influence how hormones are produced along the hypothalamus-pituitary-target gland axis, which can result in metabolic issues [14]. In regions of the world where nickel levels are high, thyroid dysfunction may arise [15]. Thyroid hormones are involved in a wide range of bodily processes, including growth, development, and an increase in baseline metabolic rate. They also affect protein synthesis and control the metabolism of proteins, lipids, and carbohydrates while modifying oxygen consumption [16]. The thyroid's ability to produce and process thyroid hormones depends on trace elements. As a result, changes in trace metal levels in body fluids can cause the body's oxidant and antioxidant balance to be disrupted [17]. This may impact the endocrine system, resulting in hyperthyroidism, hypothyroidism, Graves' disease, goiter, Hashimoto's disease, and cancer in the thyroid [18].

The current study examines the potential local and systemic toxicity of metal ions produced by orthodontic appliances as well as the impact of these ions' release in saliva on thyroid hormones.

## 2. Materials and Methods:

In a specialist center for manufacturing and orthodontics in Bab Al Muadham from January 2021 to May 2021 AD, 42 saliva samples from a patient of FOA were taken before the device was placed, and 42 samples from the same patient a month later after the wire change and mouth cleaning. Mean age ± SD for the group of fixed orthodontic patients was (16 ± 2) year. After collection, the samples from the patients centrifuged (2000 x g) for (10) minutes and the supernatants were stored at (-20) ºC.

### 2.1. Determination of thyroid hormone concentrations

FT3, FT4, and TSH levels were measured using a commercially available enzyme-linked immunosorbent assay (ELISA) for the biochemical test, Bioassay Technology Company's a kit for FT3 and FT4, and Monobind Company's a kit to measure a TSH level.

### 2.2. Determination of Trace Elements

Flame atomic absorption spectrophotometer is the preferred method for the determination of nickel and chromium concentrations in saliva [19]. A chemical flame atomic was used in conjunction with a multi-wavelength atomic absorption measurement equipment (contr AA-700, Analytik Jena Corp., Japan) [20]. Nickel was measured at a wavelength of 232 nm while chromium at 350 nm.

$HNO_3$ was used to digest saliva in glass test tubes at a ratio of 1:10. (by adding 4.5 ml of $HNO_3$ to the 0.5 mL of spit samples), and the tubes were left to sit at room temperature for (6h) Atomic absorption was used to determine the levels of nickel and chromium. The proper calibration standard curve that was constructed allowed for the determination of the metal's concentration. The trace element findings were given in (mg/dl) units.

## 3. Statistical Analysis

Statistical program IBM SPSS version 25 was used in the statistical calculations. The paired samples t-test was used for the difference's analysis between patient before and after treatment with FOA. A value of the $p<0.05$ was considered statistically significant

## 4. Results

Before and after the fixed orthodontic appliance (FOA) was installed, the FT3, FT4, and TSH levels in the saliva were statistically compared. The data shown in Table 1 reveal a substantial rise ($P < 0.05$) in FT3, and FT4 hormones in patients wearing fixed orthodontic appliances, but the concentration of TSH in saliva samples between groups before and after treatment shows no significant changes ($P=0.599$).

**Table 1:** Data of the studied hormones in the Saliva before placing the fixed orthodontic patients and after installing them after a one-month duration

| Saliva samples | | | | | |
|---|---|---|---|---|---|
| **Parameters** | **Groups** | **N** | **Mean** | **±STD** | ***P* value** |
| **TSH (µIU/ml)** | Before FOA | 42 | 3.733 | 2.710 | **0.599** |
| | After FOA | 42 | 3.542 | 2.956 | |
| **FT3 (ng/l)** | Before FOA | 42 | 284.310 | 133.874 | **0.002**** |
| | After FOA | 42 | 366.980 | 126.582 | |
| **FT4 (µg/dl)** | Before FOA | 42 | 8.0318 | 7.349 | **0.0008**** |
| | After FOA | 42 | 12.591 | 9.555 | |

* Significant at p<0.05 for 2-tailed.
** significant at p<0.01 for 2-tailed

The results of a study comparing the concentrations of nickel and chromium in the saliva of orthodontic patients are shown in Table 2. A statistical comparison of the concentrations of ions of nickel and chromium in saliva samples taken before and after the installation of a device for a month showed a significant increase (*P <0.05*).

**Table 2:** A comparison of ions (nickel and chromium) concentration in the saliva before placing the fixed orthodontic patients and after installing them after one-month duration

| **Saliva samples** | | | | | |
|---|---|---|---|---|---|
| **Parameters** | **Groups** | **N** | **Mean** | **±STD** | ***P* value** |
| **$Ni^{+2}$ (mg/dl)** | Before FOA | 30 | 1.557 | 0.808 | **0.0001**** |
| | After FOA | 30 | 6.920 | 1.536 | |
| **$Cr^{+3}$ (mg/dl)** | Before FOA | 30 | 47.622 | 52.322 | **0.0001**** |
| | After FOA | 30 | 129.596 | 86.828 | |

* Significant at p<0.05 for 2-tailed.
** significant at p<0.01 for 2-tailed

The estimated Pearson correlations of the investigated parameters revealed a significant positive association for FT4, TSH, Ni+2, and Cr+3, but no significant connection for FT3, as indicated in the Table 3.

**Table 3:** Pearson correlation between parameters levels in saliva of patients with fixed orthodontics appliances after one-month duration

| **Test (Saliva)** | **N** | **Pearson correlations** | ***P* value** | **$R^2$** |
|---|---|---|---|---|
| **FT3** | 42 | **0.253** | 0.106 | **0.064** |
| **FT4** | 42 | **0.555**** | 0.001 | **0.308** |
| **TSH** | 42 | **0.664**** | 0.003 | **1.674** |
| **$Ni^{+2}$** | 30 | **0.465**** | 0.01 | **0.217** |
| **$Cr^{+3}$** | 30 | **0.818**** | 0.001 | **0.67** |
| *****P value is highly significant at the < 0.001*** | | | | |

## 5. Discussion

In biological monitoring, saliva is one of the most important bodily fluids for nickel and chromium analysis. As a result, saliva was utilized in the current investigation to monitor the amounts of FT3, FT4, TSH, nickel, and chromium ions and look for any systemic effects on the thyroid gland.

Based on the findings of this study and several earlier investigations discovered that thyroid illness impacts salivary gland function, particularly in those with hypopituitarism who develop noticeably following therapy or medication. Salivary deficiency illness has been connected to a number of oral conditions that negatively impact a person's quality of life, such as atypical dental caries, oral mucosal inflammation, trouble eating, and poor breath [21].

These findings are in agreement with those of Renata Bandeira Lages et al. They discovered that patients having metal fix orthodontic treatment had greater nickel and chromium concentrations in their saliva than patients receiving cosmetic appliances, indicating that the kind of appliance utilized had a substantial effect on these chemical element concentrations [22]. It has been demonstrated that a Ni-Ti alloy has much greater corrosion resistance in physiological saline solutions than Co-Cr alloys and stainless steel [23]. Variable results were observed in prior studies that followed lengths of therapy with fixed orthodontic appliances [24]. Nickel and chromium concentrations in the saliva of individuals with fixed orthodontics were greater [25]. The two metals that cause contact dermatitis the most frequently are nickel and chromium [26]. Additionally, they have the potential to lead to cardiovascular failure, miscarriage, birth abnormalities, renal and lung illness, as well as breast and lung cancer [27].

Nickel (Ni) and Chromium (Cr) are present in the majority of metal alloys used to make brackets, and these elements provide these materials with their respective physical and mechanical qualities [28]. The metals released may be damaging to the patient, causing allergic responses, hypersensitivity, and mucosal sores once they are inserted [29].

## Conclusion

In conclusion, the current search revealed a statistically significant change in salivary FT3 and FT4 levels as well as corrosive Ni and Cr ion concentrations before and after 4 weeks of therapy. The use of Ni-Ti arch wires in this study and the introduction of various fixed orthodontic appliances led to the discovery that the release of ions in saliva resulted in symptoms that suggested saliva's impact on thyroid hormones and the human body. These ions were released as a result of corrosion caused by direct contact between fixed orthodontic appliances and saliva.

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