THE EFFECT OF GREEN BETEL LEAF EXTRACT IMMERSION ON NICKEL ION RELEASE IN STAINLESS STEEL ORTHODONTIC BRACKET

(PENGARUH PERENDAMAN EKSTRAK DAUN SIRIH HIJAU TERHADAP PELEPASAN ION NIKEL PADA BRACKET ORTODONTI STAINLESS STEEL)

Nety Trisnawaty[1*], Aufa Nida Fathiya[2]
[1]Department of Orthodontics, Faculty of Dentistry, Universitas Prof. Dr. Moestopo (Beragama), Jakarta, Indonesia
[2]Faculty of Dentistry, Universitas Prof. Dr. Moestopo (Beragama), Jakarta, Indonesia

*Corresponding author
netypane@gmail.com

JHDS.unjani.ac.id/jite
Doi: 10.54052/jhds.

Article History
Received: 23/02/2023
Accepted: 20/03/2023

ABSTRACT

The orthodontic bracket is an essential component in fixed orthodontic appliances. One of the materials commonly used in orthodontic brackets is stainless steel. Stainless steel orthodontic brackets have good deformation and corrosion resistance. Still, corrosion resistance is compromised by certain conditions in the oral cavity, such as salivary pH due to food and beverage consumption and toothpaste and mouthwash. One of the herbal plants that are widely used for dental and oral health is green betel leaf. Green betel leaves have an acidic pH that may cause corrosion. Corrosion has a detrimental effect on the brackets because it causes a continuous loss of nickel ions. The purpose is to determine the number of nickel ions released from stainless steel orthodontic brackets due to immersion in the green betel leaf extract. This type of research is a laboratory experimental research design with a post-test control group design. The test was carried out on 27 samples divided into three groups. Brackets were immersed in 25% green betel leaf extract, artificial saliva, and a mixture of 25% green betel leaf extract and artificial saliva for 48 hours and measured using an Atomic Absorption Spectrophotome (AAS). The results showed the most significant release of nickel ions occurred in the 25% green betel leaf extract group with a value of 16.37 mg/Kg, and the minor release of nickel ions occurred in the artificial saliva control group with a weight of 1.95 mg/Kg. The conclusion is that green betel leaf extract influences the release of nickel ions in stainless steel orthodontic brackets.

Keywords: green betel leaf; nickel; orthodontic bracket

ABSTRAK

Bracket ortodonti merupakan komponen penting dalam peranti ortodonti cekat. Salah satu bahan yang umum digunakan adalah stainless steel. Bracket ortodonti stainless steel memiliki deformasi dan ketahanan korosi yang baik, tetapi juga dapat menimbulkan terjadinya korosi akibat kondisi tertentu di dalam rongga mulut, seperti pH saliva akibat pengaruh makanan, minuman, serta penggunaan pasta gigi dan obat kumur. Salah satu tanaman herbal yang banyak digunakan untuk kesehatan gigi dan mulut adalah daun sirih hijau. Penggunaan daun sirih hijau dapat menyebabkan terjadinya korosi karena memiliki pH yang asam. Korosi menimbulkan efek yang merugikan pada bracket karena menyebabkan hilangnya ion nikel secara terus-menerus. Tujuan penelitian ini untuk mengetahui jumlah ion nikel yang terlepas dari bracket ortodonti stainless steel akibat direndam dalam ekstrak daun sirih hijau. Jenis penelitian ini adalah eksperimental laboratorium dengan desain penelitian post-test control group design. Pengujian dilakukan pada 27 sampel yang dibagi menjadi tiga kelompok. Bracket direndam dalam ekstrak daun sirih hijau 25%, saliva artifisial, dan campuran ekstrak daun sirih hijau 25% dan saliva artifisial selama 48 jam dan diukur menggunakan alat Atomic Absorption Spectrophotome (AAS). Hasil penelitien didapat bahwa pelepasan ion nikel terbesar *terjadi pada kelompok ekstrak daun sirih hijau 25%, yaitu 16,37 mg/Kg, sedangkan pelepasan ion nikel terkecil terjadi pada kelompok kontrol saliva artifisial, yaitu 1,95 mg/Kg. Kesimpulannya adalah Ekstrak daun sirih hijau berpengaruh terhadap terjadinya pelepasan ion nikel pada bracket ortodonti stainless steel.*

Kata kunci: *bracket ortodonti; daun sirih hijau; nikel*

INTRODUCTION

Orthodontic treatment aims to increase the function of the orofacial region by correcting misalignment, preventing malocclusion, and growing facial aesthetics that could affect an individual's mental and physical well-being.[1,2] Instruments used in orthodontic treatment have to fulfill specific requirements such as biological safety and efficiency, adequate tissue response, and able to prevent corrosion.[2] The most common treatment modality for treating various malocclusion is fixed orthodontic treatment.[3] Fixed orthodontic appliance is placed on the tooth surface with chemical interlocking or micro mechanic. Fixed appliances can perform higher tooth movement compared to removable appliances.[4] An orthodontic bracket is one of the main components of a fixed orthodontic appliance.[3]

Brackets can transmit force from the wire to the tooth structure and supporting tissues to create tooth movement.[5] The most used brackets are stainless steel brackets. The main components of stainless steel are 8-12% nickel (Ni) and 17-22% chromium (Cr). Stainless steel brackets are used for their properties, such as good deformation and corrosion resistance, low cost, higher elastic modulus, and excellent biomechanical properties.[6] However, stainless steel also has disadvantages under certain conditions, such as changes in temperature, saliva, plaque, and the pH of the oral cavity due to the influence of food and beverage consumption, as well as the use of toothpaste and mouthwash containing fluoride and chloride that promotes corrosion.[7]

Corrosion is damage in a material caused by chemical reaction between the material, and its environment.[8] Corrosion can increase orthodontic friction between archwire and bracket due to increased surface roughness. Corrosion may also cause staining of the enamel after bracket removal.[6] Many factors in the oral environment can promote the corrosion of metal orthodontic appliances, such as temperature, salivary pH, fluoride, bacterial flora, enzyme activity, and protein.[8] Corrosion products released from stainless steel brackets include Nickel, manganese, iron, chromium, and copper.[9] Nickel is the most common metal that causes contact dermatitis. In addition, Nickel may cause adverse effects on the human body, either in the form of hypersensitivity reactions, cancer triggers, or toxicity.[8,10]

Betel leaves were used in dental and oral health to protect teeth, treat dental caries, prevent bad breath, canker sores, and used as a mouthwash.[11] Green betel leaf (*Piper betle Linn.)* is a medicinal plant in the *Piperaceae* family which contains secondary metabolites that can be used for the main component of traditional medicine.[12] Almost every part of the betel plant has unique chemical content, especially the leaves and stems of the betel, which contain many essential oils.[13] The essential oil contained in betel leaves has also been shown to be effective as an antiseptic. Other than its antiseptic use, betel leaf is effective as an anti-inflammatory and antibacterial agent.[12]

Figure 1. Piper betel Linn.[12]

This experiment examines nickel ion release from orthodontic stainless-steel brackets after immersion in the green betel leaf extract.

METHOD

This research used experimental laboratory research with a post-test control group design. This research was conducted in the Testing and Certification Services Laboratory Unit, Bogor Agricultural Institute, and green betel leaf extract was manufactured in Yarsi University Herbal Laboratory in May-June 2022. The research sample was maxillary Mini Roth stainless steel orthodontic brackets with a 0.022-inch diameter which were immersed in three group tests comprising 25% green betel leaf extract, artificial saliva, a mixture of green betel leaf extract, and artificial saliva. The sample size was determined using the Federer method.

The results showed that each group's minimum number of samples is more significant than 8.5, making up to 9 samples. Because there are three groups, the total number of pieces is 27 samples.

The first step was producing 25% green betel leaf extract using the maceration method. Five hundred grams of dried green betel leaves were cut into small pieces and mixed with 96% ethanol solvent. The extraction process was carried out for five days in a place protected from light, and then the dregs were macerated for two days. The extract was distilled using a rotary evaporator to obtain a thick green betel leaf extract. After that, 2.5 grams of green betel leaf extract and 10 ml of distilled water were added to the thick extract to obtain a concentration of 25%.

Figure 2. Dried green betel leaf.

After preparing the 25% green betel leaf extract, the samples were grouped, each consisting of 9 maxillary stainless steel orthodontic brackets. Stainless steel brackets were immersed and stored in an incubator for 48 hours at 37ºC. After 48 hours, the brackets were separated from the test solution and continued with an analysis of the nickel ion release that occurred using an Atomic Absorption Spectrophotome (AAS).

Data analysis was performed using the Shapiro-Wilk normality test and Levene homogeneity test. The normality and homogeneity test results were fulfilled; hence the data were processed with a parametric test using One-Way ANOVA.

RESULT

The average value of nickel ion release in stainless steel orthodontic brackets soaked in 25% green betel leaf extract, artificial saliva, and a mixture of green betel leaf extract and artificial saliva are shown in Table 1.

Table 1. The average amount of release of nickel ions after immersion in the three test groups

Group	Mean	St.dev
Artificial Saliva	1,95	0,059
Betel Leaf Extract + Saliva	3,78	0,061
25% Betel Leaf Extract	16,37	0,067

Table 1 shows that the highest value of nickel ion release is seen in the bracket group soaked in 25% betel leaf extract with a mean weight of 16,37 +/-SD mg/Kg. The lowest value of nickel ion release is seen in the artificial saliva group, with a mean value of 1,95 +/-SD mg/Kg.

Table 2. Shapiro-Wilk normality test results

Group	Sig *Shapiro-Wilk Ion Nickel*	Results
Artificial Saliva	0,999	Normal
Betel Leaf Extract + Saliva	0,688	Normal
25% Betel Leaf Extract	0,915	Normal

The results of the Shapiro-Wilk normality test showed that the nickel ion release data were normally distributed (sig > 0,05). Thus, the homogeneity test followed the comparative test (Table 3).

Table 3. Levene homogeneity test results

Data	*Levene's Test*	
	Sig	Result
Nickel Ion Release	0,782	Homogenous

Levene homogeneity test results showed that the data on the number of nickel ions has a value of 0.782 (sig Levene Test > 0.05), which indicates homogeneous data variety. The requirements for normality and homogeneity have been met; thus, the

One-Way ANOVA test was used to determine the effect of immersing green betel leaf extract on the release of nickel ions in stainless steel orthodontic brackets (Table 4).

Table 4. One-Way ANOVA Test

	Sum of Squares	**df**	**Mean Square**	**F**	**Sig.**
Between Groups	1109.30	2	554.690	141322.318	0.000
Within Groups	0.094	24	0.004		
Total	1109.44	26			

The results of the One-Way ANOVA test showed that the sig value of the F test was 0.000 (sig <0.05), which indicated that there was an effect of soaking green betel leaf extract on the release of nickel ions in stainless steel orthodontic brackets in the three treatment groups.

DISCUSSION

The results showed more nickel ions were released in the 25% green betel leaf extract treatment group and the 25% green betel leaf extract mixture and artificial saliva group compared to the artificial saliva control group. Green betel leaves contain water, protein, carbohydrates, minerals, fat, fiber, essential oils, tannins, and alkaloids (araken). In addition, it also has different vitamins, such as vitamin C, nicotinic acid, vitamin A, thiamine, and riboflavin.[14] The protein and vitamin C content of green betel leaves can affect the release of metal ions because they can act as electrolyte media that can trigger electrochemical reactions. This reaction can be an early sign of corrosion.[8,15]

The results of this study are in line with the research conducted by Dundu et al. (2017) regarding the release of metal ions (Ni, Cr, and Fe) that occur in orthodontic brackets due to immersion in 50% betel leaf extract solution, aquabidest, artificial saliva and sodium fluoride. Based on the results of this study, the highest ion release occurred in the 50% green betel leaf extract solution group, and the minor release of Ni and Fe ions was in the group immersed in saliva.[15] The difference in nickel ion release in the two test groups was due to the difference in pH between green betel leaf extract and artificial saliva. Green betel leaves have a pH of 4.9 which indicates acidity.

The study results in the control group with stainless steel orthodontic brackets immersed in artificial saliva also showed the release of nickel ions. The ion release was caused by saliva's organic and inorganic components, such as sodium, chloride, potassium, bicarbonate ions, calcium, magnesium, hydrogen phosphate, thiocyanate, and fluoride.[8] Chloride ions in saliva can damage the oxide layer on the bracket's surface, releasing metal ions, one of which is Nickel. Nickel ions have soluble properties in the salivary fluid. Hence the duration of contact between the bracket and saliva can affect the release of metal ions. The release of nickel ions occurs more at acidic than normal pH. In acidic conditions, the number of H+ ions will be more significant, so they are corrosive and can oxidize metals. The release of nickel ions can reduce the strength of stainless steel because Nickel increases strength and flexibility and improves corrosion resistance.[16] Corrosion of stainless steel can create surface roughness in the form of pits and scratches on the corroded surface. Surface roughness causes an increase in frictional forces. Friction can reduce the efficiency of orthodontic appliances and decrease the speed of tooth movement.[17]

Based on the results of this study, the release of nickel ions that occurred in the tested stainless steel orthodontic brackets was still within safe limits. The average daily intake of Nickel from food sources is 200–300 µg, while the concentration of Nickel in drinking water is generally below 20 µg/L. Excessive nickel ion release can cause type IV hypersensitivity reactions, gingival overgrowth, angular cheilitis, and labial desquamation dermatitis.19,20 Nickel can also cause harmful effects at the cellular, tissue, organ, and organism level. In higher doses, Nickel can be allergenic or carcinogenic and act as a mutating agent by causing changes in DNA.[21]

CONCLUSION

This research showed that the most significant release of nickel ions occurred in stainless steel orthodontic brackets immersed in 25% green betel leaf extract with a value of 16.37 mg/Kg. The release of nickel ions in the mixed group of 25% green betel leaf extract and artificial saliva was 3.78 mg/Kg. The two treatment groups resulted in a more significant release of nickel ions than the artificial saliva control group, which was 1.95 mg/Kg. The amount of nickel ions released is still within safe limits. If a higher dose of nickel ion is released, it can cause various adverse effects on the body and reduce the corrosion resistance of stainless steel brackets. Corrosion can cause an increase in frictional forces, thereby reducing the efficiency of orthodontic appliances and decreasing the speed of tooth movement.

CONFLICT OF INTEREST

The author declared no conflicts of interest or potential commercial background in this research.

ACKNOWLEDGEMENT

Our thanks go to the professionals who assisted in the research and preparation of the paper.

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