

REVIEW ARTICLE

Nickel Allergies in Orthodontic Treatment

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ABSTRACT

Nickel (Ni) is a common component in many orthodontic materials. The dental practitioner should be mindful of this allergy during the course of orthodontic treatment, and know how to diagnose a Ni allergy if it appears and subsequent action in treatment and referral if it is suspected. This paper provides a summary of Ni allergy, its epidemiology, diagnosis, and recommendations, and alternatives to treatment. A detailed description of two cases where it was discovered in orthodontic patients is also reported.

Keywords: Allergies, Alloys, Nickel ions, Orthodontic material.

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INTRODUCTION

Nickel (Ni)-containing alloys have become an integral part of almost every routine orthodontic intervention.¹ As known, contemporary orthodontics relies on various bonded attachments, archwires, and other devices to achieve tooth movement. The demands made on them are complex because they are placed under many stresses in the oral environment, which include immersion in saliva, ingested fluids, temperature fluctuations, and masticatory force. The orthodontic appliances, i.e., orthodontic bands, brackets, and archwires were introduced in 1930s. Since then, alloys have become an invaluable material in orthodontics, which are made of stainless steel containing 8 to 12% Ni, 17 to 22% chromium, and various proportions of manganese, copper, titanium, and iron.² These are extremely durable and relatively inexpensive. The combination of the alloys materials is in close proximity and in hostile conditions leading to

corrosion and adverse reaction biologically and increase the friction mechanically. When using nickel–titanium (NiTi) archwire for dental orthodontic treatment, the possible danger associated with archwire corrosion derives from the biologically harmful effects due to the released Ni ion.³ Therefore, NiTi archwire with a good corrosion resistance is crucial to its biocompatibility. On the contrary, the surface corrosion of NiTi archwires may increase the friction that appears at the interface between the archwire and bracket, reducing the free sliding action during orthodontic treatment.⁴

IMMUNE RESPONSE

The response by the immune system to Ni is usually a type IV cell-mediated delayed hypersensitivity also called an allergic contact dermatitis. It is mediated by T-cells and monocytes/macrophages rather than antibodies and consists of two phases. The first phase, or sensitization, occurs when Ni initially enters the body. There is usually no response present at this time but the immune system is primed or sensitized for an allergic response. The major sensitization routes are Ni-containing jewelry and foods. Foods that are high in Ni include chocolate, soy beans, nuts, and oatmeal. A response, or the elicitation phase, is in the form of a contact mucositis or dermatitis that occurs during re-exposure to Ni and develops over a period of days or rarely up to 3 weeks. If Ni is leached from orthodontic appliances, this type IV hypersensitivity reaction can occur.⁵

EPIDEMIOLOGY

Nickel allergy occurs more frequently than allergy to all other metals combined. It is estimated that 11% of all women and 20% of women between the ages of 16 and 35 years have a sensitivity to Ni.⁶ The sensitivity of males is only 2%, likely due to the decreased contact of Ni from jewelry. Fortunately, most individuals who have Ni sensitivity do not report adverse clinical manifestations to orthodontic appliances containing Ni. It is estimated that the occurrence of a harmful response by patients to Ni is 0.1 to 0.2%.⁷ It is thought that a much greater concentration of Ni in the oral mucosa than the skin is necessary to elicit an allergic reaction.⁸ Furthermore, the incidence of an allergic response to stainless steel orthodontic brackets has not been reported; however, there have been some reported cases.⁹ Nickel leaching

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of orthodontic bands, brackets, and stainless steel or NiTi archwires has been shown *in vitro* to maximally occur within the 1st week and then decline thereafter.¹⁰ This coincides with the approximate timeframe for type IV hypersensitivity reactions. Saliva or certain intraoral conditions, such as foods, oral hygiene products, and fluoride may potentially corrode the Ni in the alloy and release it onto the oral mucosa. Nickel–titanium orthodontic wires in combination with fluoride media have been shown to release significantly more Ni ions in artificial saliva.¹¹ Also, NiTi archwires, especially when they contain copper, have been shown to corrode in the presence of fluoride mouthwash. This has implications not only in the development of contact sensitivity reactions but also in decreased mechanical properties of the wire.¹² The amount of corrosion from different alloys, however, has not been clinically demonstrated. Factors including intraoral temperature, pH, salivary composition, duration of exposure, wear of the wire due to friction from sliding mechanics, abrasion, presence of solder, strain of the wire, and most importantly, the amount of Ni, i.e., leached are factors determining the concentration of Ni present from a particular appliance.¹³ Other factors predisposing patients to Ni allergy include genetics¹⁴ and the presence of certain major histocompatibility complex haplotypes.¹⁵ Nickel sensitivity has also been found to be higher in asthmatic patients.¹⁶

DIAGNOSIS

The diagnosis of Ni allergy has usually been based on patient history, clinical findings, genetic factors, and the results of patch testings. In the patch test, 5% Ni sulfate in petroleum jelly is used. Lesions due to mechanical irritation and allergies to other materials, such as acrylic should be ruled out.¹⁵

Extraoral

- Generalized urticaria
- Widespread eczema
- Flare up of allergic dermatitis
- Exacerbation of preexisting eczema.

Intraoral

- Stomatitis from mild to severe erythema
- Papulaperi oral rash
- Loss of metallic taste
- Numbness
- Burning sensation
- Soreness at side of the tongue
- Angular cheilitis severe gingivitis in the absence of plaque.¹⁰

Possible Risks associated with Nickel Toxicity

The literature has shown many *in vivo* and *in vitro* studies documenting the corrosion of orthodontic appliances, and the release of metal ions are indisputable. It has been reported that the adjacent oral tissues take up metal ions.^{16,17}

Risk of Nephrotoxicity

Sunderman¹⁵ reported a patient with documented IgA nephropathy.

Risk of Cytotoxicity

Grimsdottir et al⁵ used the agar overlay cytotoxicity test with mouse fibroblast cells and reported that none of the archwires tested caused by cytotoxic effect. The study carried out by Hafez et al¹⁶ proved the cytotoxicity and genotoxicity of orthodontic appliances remained in the mouth for 6 months.

Risk of Carcinogenicity

Sunderman¹⁵ and Mastromatteo¹⁷ reported that Ni subsulfide, Ni oxide, and metallic Ni dust have been suspected to be the principal respiratory carcinogens.

Risk of DNA Damage

Several studies conducted by Faccioni et al,¹⁸ Hafez et al,¹⁶ and Fernández-Miñano et al¹⁹ suggested the DNA damage in buccal mucosal cells²⁰ and Heravi et al²¹ suggested that DNA damage induced by orthodontic appliance would repair in healthy individuals, but decrease in repair capacity or alterations in the immune system may allow the DNA damage to remain and expressed as genome alteration and DNA mutations. Older age, presence of systemic diseases, and risk factors, such as tobacco smoke may also aggravate the harmful effects of fixed appliances.²¹

The study by Das et al²² showed that Ni-ion leaching from appliances can also generate free radicals, resulting in oxidative stress in cell and tissue level.

Risk of Immune Changes and Alveolar Bone Loss

Lamster et al²³ reviewed two cases of women who demonstrated significant alveolar bone loss around Ni-rich nonprecious alloy and porcelain crown. A type IV hypersensitivity reaction was observed which might have caused the loss of the alveolar bone.

Risk of Sensitivity

Nickel dermatitis could be seen of two types. First type of dermatitis is described as a reaction on the skin

characterized by itching or burning, popularly seen as erythemas in the web of the fingers, which would spread to the fingers, wrist, and forearms. A second type of Ni dermatitis was described as papulo-vesicular dermatitis with a tendency for lichenification.¹¹

Treatment

If intraoral signs and symptoms are present and a diagnosis of Ni hypersensitivity is established, the NiTi archwire should be removed and replaced with a stainless steel archwire which is low in Ni content or preferably a titanium molybdenum alloy (TMA), which does not contain Ni. Stainless steel is slightly less expensive than NiTi archwires, while TMA is slightly more. Resin-coated NiTi wires are also an option. These resin-coated wires have had their surface treated with nitrogen ions, which forms an amorphous surface layer. Manufacturers claim that this results in an increase in corrosion resistance and decreased amount of leaching of Ni, more so than both NiTi and stainless steel wires.²⁴ Most patients who develop a reaction to NiTi archwires subsequently tolerate stainless steel without a reaction.²⁵ This is believed to be a result of the Ni being tightly bound to the crystal lattice of the alloy, rendering them unable to be leached into the oral cavity. Stainless steel has been shown to release low amounts of Ni in artificial saliva or sweat which could help account for its low allergenicity.²⁶ In the rare event that the patient continues to manifest an allergic reaction, all stainless steel archwires and brackets should be removed. If any severe allergic reaction develops, the patient should be referred to a physician to be treated with antihistamines, anesthetics, or topical corticosteroids.²⁷ Attempts should be made to complete orthodontic treatment with TMA, fiber-reinforced composite, pure Ti, or gold-plated wires. The most commonly used orthodontic brackets that do not contain Ni include ceramic brackets produced using polycrystalline alumina, single-crystal sapphire, and zirconia. Other Ni-free alternative brackets include polycarbonate brackets made from plastic polymers, titanium brackets, and gold brackets. Another alternative for certain treatments is the use of plastic aligners, such as Invisalign™.

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