SHORT COMMUNICATION

Nickel Allergy and Orthodontics

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ABSTRACT

Nickel is a component of nickel-titanium and stainless steel alloys which are widely used in orthodontic appliances. Level of nickel in saliva and serum increases significantly after the insertion of fixed orthodontic appliances. A threshold concentration of approximately 30 ppm of nickel may be sufficient to elicit a cytotoxic response. Experimental and clinical studies indicate that oral exposure to nickel-containing alloys may reduce the chance of nickel sensitization by later exposure to the metal, i.e., induce a certain tolerance Alternatives include twistflex stainless steel, fibre-reinforced composite archwires, TMA, pure titanium, and gold-plated wires may also be used without risk.

Key words: Nickel, Type IV hypersensitivity, Sensitization, Nickel dermatitis

INTRODUCTION

Nickel is one of the most commonly used metals, as it is a component of nickel-titanium and stainless steel alloys which are widely used in orthodontic appliances. Nickel-titanium alloys may have nickel content in excess of 50 percent and can thus potentially release enough nickel in the oral environment to elicit manifestations of an allergic reaction. Stainless steel has lower nickel content (8 percent). However, because the nickel is bound in a crystal lattice it is not available to react. Stainless steel orthodontic components are therefore very unlikely to cause nickel hypersensitivity.[1]

Biology of the reaction

An allergic response is one in which certain components of the immune system react excessively to a foreign substance. Nickel elicits contact dermatitis, which is a Type IV delayed hypersensitivity immune response.[2] This process has two interrelated, distinct phases. A sensitization phase occurs from the moment the allergen enters the body, is recognized and a response occurs. And an elicitation phase occurs after re-exposure to the allergen to the appearance of the full clinical reaction. There may have been no symptoms at the initial exposure, but subsequent exposure leads to a more visible reaction.

Occurrence of nickel allergy

It has been shown that the level of nickel in saliva and serum increases significantly after the insertion of fixed orthodontic appliances.[3] Nickel is the most common metal to cause contact dermatitis in orthodontics, with more cases of allergic reactions than all the other metals combined.[4] Once hypersensitivity has been established, all oral mucosal surfaces can be involved. It has been suggested that a threshold concentration of approximately 30 ppm of nickel may be sufficient to elicit a cytotoxic response day.[5,6,7] It has also been reported that the in vitro release rate for full mouth orthodontic appliances is 40 micrograms/day for nickel.[8] For heat-treated stainless steel orthodontic archwire, the release rate for nickel was found to be 0.26 microgram/cm^2 per day.[9] Barrett *et al.*[10] reported that the release rate for nickel from stainless steel or nickel titanium wires are not significantly different.

Diagnosis of nickel allergy

It is important to make a correct diagnosis of nickel allergy, symptoms of which may occur either within or remote to the oral environment. The following patient history would suggest a diagnosis of nickel allergy:

- previous allergic response after wearing earrings or a metal watchstrap;
- appearance of allergy symptoms shortly after the initial insertion of orthodontic components containing nickel;
- confined extra-oral rash adjacent to headgear studs.

A dermatologist should confirm the diagnosis by patch testing using 5 per cent nickel sulfate in petroleum jelly. Lesions due to other causes like Candidiasis; Herpetic stomatitis; Ulcers due to mechanical irritation; allergies to other materials such as acrylic should be ruled out. [11]

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Possible risks associated with nickel toxicity

1. Risk of Nephrotoxicity: Sundermann[11] reported a patient with documented IgA nephropathy.
2. Risk of Carcinogenecity: Sunderman *et al.*[11,12,13] and Mastromatteo[134,135] reported that nickel subsulphide, nickel oxide and metallic nickel dust have been suspected to be the principal respiratory carcinogens.
3. Risk of immune changes and alveolar bone loss: Lamster et al[14] reviewed two cases of women who demonstrated significant alveolar bone loss around nickel-rich non-precious alloy and porcelain crown. A Type IV hypersensitivity reaction was observed which may have caused the loss of the alveolar bone.
4. Risk of Cytotoxicity: Grimmsdottir *et al.*[15] used the agar overlay cytotoxicity test with mouse fibroblast cells and reported that none of the archwires tested caused by cytotoxic effect whereas the multicomponent devices.
5. Risk of Sensitivity: Nickel dermatitis could be of two types. Firstly, "nickel itch", which is a skin disease characterized by itching or burning popular erythemas in the web of the fingers which would spread to the fingers, wrist and forearms. A second type of nickel dermatitis was described as a popular or papulo-vesicular dermatitis with a tendency for lichenification.

The Role of Orthodontically Derived Nickel

Patch testing of about 700 Finnish adolescents showed no difference in the frequency of nickel sensitivity between previous orthodontic patients with fixed appliances and individuals who had received no orthodontic treatment.[16]

Actually, experimental and clinical studies indicate that oral exposure to nickel-containing alloys may reduce the chance of nickel sensitization by later exposure to the metal; i.e., induce a certain tolerance. A large-scale European study on orthodontic patients tested in dermatology clinics indicated that treatment of young girls with archwires and metal brackets induced a partial tolerance for the T cell-mediated allergy induced by ear piercing that strongly participates in the development of nickel hypersensitivity. The prevalence of nickel hypersensitivity was higher in the group with pierced ears fitted with braces after ear piercing. The Finnish study[16] showed similar results. Children who started orthodontic treatment before ear piercing had significantly lower prevalence of nickel hypersensitivity as compared to patients starting orthodontic treatment after ear piercing.

Spiechowicz[17] attempted to explain the lack of an intraoral response by four different mechanisms.

1. Formation of salivary glycoprotein films that act as diffusion barriers.
2. Differences in the permeability of the skin and the oral mucosa.
3. Cellular hypersensitivity mechanisms differ between the skin and the oral mucosa.
4. Differences in the distribution and function of Langerhans cells.

Orthodontics and Previously Nickel-Sensitized Patients

An orally induced nickel tolerance by orthodontic arch wires and brackets does not eliminate the possibility of nickel sensitization by the extraoral parts of orthodontic appliances, similar to that from other nickel-containing objects with skin contact, nor does it prevent the expression of nickel allergy to orthodontic materials in previously sensitized patients. Case reports and epidemiological surveys indicate that adverse reactions occur more frequently extraorally than intraorally and that allergic reactions are difficult to distinguish from irritative reactions by clinical inspection alone. Generalized and serious allergic reactions to nickel-containing orthodontic appliances do occur. Their reactions can be characterized by eczematous reactions of the knee and elbow flexures, generalized eczematous reactions on the trunk and extremities, general malaise, and eczemas of the wrists. These responses are observed following the insertion of nickel-containing orthodontic devices such as space retainers, arch wires, or molar bands in previously sensitized patients.[18]

Most reactions were attributed to causes such as mechanical injuries and acrylic allergy. Patch testing of the remaining patients, together with some patients reporting extraoral discomfort showed the existence of nickel allergy in only one girl who exhibited aphthous ulcers. All other girls tested negative to nickel sulfate. However, the aphthae did not disappear upon removal of the orthodontic appliances. It was concluded that nickel allergy did not lead to an increased prevalence of allergic reactions following orthodontic treatment. Of the nine girls tested, six were classified as atopics.

A fair conclusion would be that nickel allergy following orthodontic treatment does occur in previously sensitized patients, but at a very low incidence. Extraoral reactions are significantly more frequent than intraoral reactions. Nickel sensitization of patients with intraoral orthodontic devices is highly improbable, whereas sensitization with extraoral devices cannot be excluded. Irritant reactions are sometimes difficult to distinguish from allergic reactions and nickel may not always be the "culprit."

Archwires

Stainless steel: The majority of investigations have shown that nickel sensitive patients are able to tolerate stainless steel without any noticeable reaction and this is thought to

be due to the crystal lattice of the alloys binding the nickel, which is then not free to react.[19] The publications to report an allergic response to stainless steel wire re those where the stainless steel was used for intermaxillary or internal fixation, had increased nickel content and were not tested for corrosion.[20,21] Most research concludes that stainless steel is a safe material to use for all intra-oral orthodontic components for nickel sensitive patients. Reduced nickel content stainless steel is also available, but appears to be unnecessary.

Nickel-titanium: Flexile nickel-titanium wires release increased amounts of nickel and are thought to induct nickel sensitivity; there may be up to 20 per cent conversion rate.[22] These high nickel content wires should be avoided in nickel sensitive patients. Alternatives include twistflex stainless steel, fibre-reinforced composite archwires. Wires such as TMA, pure titanium, and gold-plated wires may also be used without risk. Altered nickel-titanium archwires also exist and include plastic/resin-coated nickel-titanium archwires.[23] Ion-implanted nickel-titanium archwires have their surface bombarded with nitrogen ions, which forms an amorphous surface layer, conferring corrosion resistance and displacing nickel atoms. Manufacturers claim that these altered nickel-titanium archwires exhibit less corrosion than stainless steel or non-coated nickel-titanium wires, which results in a reduction of the release of nickel and decrease the risk of an allergic response.

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