

Adverse reactions to orthodontic appliances in nickel-allergic patients

Kristen K. Volkman, M.D.,* Michael J. Inda, D.D.S., M.S.,# Peter G. Reichl, D.D.S., M.S.,# and Michael C. Zacharisen, M.D.*

ABSTRACT

Nickel allergy (NA) is common and causes more cases of allergic contact dermatitis (ACD) than all other metals combined. Many orthodontic appliances (ODAs) contain nickel but their clinical relevance in nickel-allergic patients is unclear. We aimed to characterize the relationship between NA and ODAs because the medical literature investigating this is controversial. A survey concerning adverse reactions to ODAs in patients with NA was distributed to members of the Wisconsin Society of Orthodontics. Forty-three surveys were analyzed. The surveyed group was experienced, representing a mean of 21.2 years in practice and averaging 242 appliances placed per year per orthodontist. Most new patients with orthodontia were 10–18 years old. Most wires used were nickel–titanium alloy. Although 76% of orthodontists inquired about NA at initial evaluation, 37% still placed nickel-containing ODAs in known nickel-allergic patients. Fifty percent placed a single intraoral appliance, observing for reactions. Three orthodontists applied ODAs to the skin similar to patch testing. Only 8 patients with reactions to ODAs were described in detail, 6 were female patients and 6 were aged 13–14 years. Intraoral and extraoral reactions were mild; diffuse urticaria was reported in one patient. Treatment included removing the appliances or changing to nonnickel alternatives with favorable outcomes. These cases, which included >33,000 patients, suggest a prevalence of 0.03%. Adverse reactions to ODAs in patients with NA have been observed but are uncommon. Using suitable alternatives, patients usually can be accommodated.

(Allergy Asthma Proc 28:480–484, 2007; doi: 10.2500/aap.2007.28.3018)

Key words: Adverse reaction, contact dermatitis, dental, nickel allergy, orthodontics, patch testing, urticaria

Nickel allergy (NA) is common with a prevalence of 10–15%¹ and occurs worldwide. Because of the high rate of NA, the Danish Ministry of the Environment issued legislation in 1991 prohibiting the sale and regulating the labeling of nickel-containing products.² In 2000, this legislation was expanded³ and the European Union adopted similar restrictions in 1994 and 2004.^{4,5} Studies in 2002 indicate that in Denmark, the prevalence of NA has decreased.⁶

The most common manifestation of NA is allergic contact dermatitis (ACD), a type IV T-cell-mediated delayed-type hypersensitivity reaction. ACD occurs in areas where skin contacts nickel-containing objects such as costume jewelry, snaps on clothing, eyeglasses, and watches. Occupational and industrial arenas also can be a source of nickel exposure. Allergic contact urticaria to nickel has been reported.⁷

NA is more common in women by two- to sixfold, presumably because of ear piercing being the sensitizing event where intimate contact between nickel-plated earrings and injured skin occurs.⁸ Use of nickel-plated earrings in combination with other irritants such as moisture or shampoo could potentiate sensitization.⁸ NA is more common in younger patients and in those who are nonatopic.

Nickel is ubiquitous and is found in foods (highest in legumes, nuts, grains, potatoes, chocolate, and fish), tap water, cosmetics, and cooking utensils.⁸ Another source of nickel is orthodontic appliances (ODAs). Nearly 5 million people in the United States and Canada undergo orthodontic treatment with 80% of patients under the age of 18 years.⁹ ODAs include intraoral (e.g., bands, brackets, and wires) and extraoral (e.g., headgear) devices that can contain 50–70% nickel.^{10,11} Although stainless steel contains 8% nickel, this alloy generally is considered safe to place in nickel-allergic patients because of its crystal lattice structure.¹¹ However, recent studies *in vivo* and *in vitro* suggest that nickel is released from stainless steel ODAs.^{12,13} A variety of nonnickel-containing ODAs exist.¹¹

Cases of NA due to ODAs have been reported in the last 30 years. A wide range of reactions has been reported such as eczema exacerbation, systemic contact dermatitis, localized dermatitis both intraorally and

From the *Section of Allergy and Immunology, Medical College of Wisconsin, Milwaukee, Wisconsin, and #Reichl Orthodontics, Waukesha, Wisconsin

Presented as a Poster at the annual meeting of the American Academy of Allergy, Asthma and Immunology, Miami Beach, Florida, March 5, 2006

This work was self-funded

Disclaimers: None

Address correspondence and reprint requests to Michael C. Zacharisen, M.D., 9000 West Wisconsin Avenue, Milwaukee, WI 53226

E-mail address: mzach@mchw.edu

Copyright © 2007, OceanSide Publications, Inc., U.S.A.

extraorally, and conjunctivitis due to brackets, wires, bands, retainers, and headgear.^{14–19} However, the role of ODAs in NA is controversial. We aimed to characterize the relationship between NA and ODAs using a survey of practicing orthodontists in Wisconsin.

MATERIALS AND METHODS

Participants and Survey Design

A confidential, written survey aimed at practicing orthodontists in Wisconsin was developed and distributed at the annual meeting of the Wisconsin Society of Orthodontists. The questionnaire was redistributed 1 month later by postal mail to improve the survey return rate.

The survey inquired about the age and number of years in practice for the orthodontist as well as demographics about their patient population such as age, the number of new patients per year that ODAs are applied, and the total and active number of patients in their practice. We asked if orthodontists inquire about NA, note body piercings, and refer these patients to a physician. For those patients who report having NA, we asked if nickel-containing ODAs are used and if a single intraoral appliance is placed as a trial. The survey inquired as to the types of wires used in their practice. Observed or suspected cases of adverse reactions to nickel-containing ODAs were solicited and patient demographics and the nature, treatment, and outcome of the reaction were requested.

Statistical Analysis

Descriptive statistics were calculated for questions on the survey.

Institutional Review Board Approval

This survey was approved by the Human Research Review Committee of the Medical College of Wisconsin and the Human Research Review Board at Children's Hospital of Wisconsin. Informed consent was obtained from each participant.

RESULTS

Of the 220 members of the Wisconsin Society of Orthodontists, 43 completed surveys were returned (20%). Twelve percent of orthodontists were aged 30–39 years of age, 28% were 40–49 years of age, 44% were 50–59 years of age, and 16% were ≥60 years of age. Their experience represents 890.5 years total (mean, 21.2 years) in practice. Seventy-six percent of orthodontists ask about NA in their initial evaluation of patients. Twenty-eight percent of orthodontists note body piercings on initial evaluation. Thirty-seven percent of orthodontists reported using nickel-containing ODAs in patients who are known to be nickel allergic.

Fifty percent of orthodontists have placed a single intraoral appliance in nickel-allergic patients as a trial, observing for reactions. The most commonly used wire was nickel–titanium. Sixty-eight percent of orthodontists referred nickel-allergic patients to the primary care physician, dermatology, allergy, or both in equal distribution. Three orthodontists reported applying nickel-containing wires or a bracket to the skin and observed for a reaction, similar to a patch test.

The orthodontists reported a total of 33,634 patients in their practice with 24,759 active patients. Each year, a mean of 242 new patients per orthodontist have ODAs applied. Seventeen percent of these patients are <10 years of age, 64% are between 10 and 18 years of age, and 19% are >18 years of age.

Ten orthodontists cumulatively reported 10 suspected cases of adverse reactions to nickel-containing ODAs (Table 1). This represents a prevalence of 0.03% among >33,000 patients. For two of the cases, details were not known. Among the remaining eight cases, four patients were known to be nickel allergic, three patients were not known to be nickel allergic, and the nickel-allergic status of the remaining patient was unknown. Six of the eight patients were female subjects. The ages of the patients ranged from 13 to 52 years but six patients were aged 13–14 years. Three patients had ear piercings, two patients did not have ear piercings, and piercings were not known for three patients.

In terms of the nature of the reactions, four cases were intraoral and include gingivitis, ulcers, generalized burning sensation, and mild buccal mucosa edema. Treatment varied from removing the braces, changing to nonnickel ODAs, continuing nickel–titanium wires, and applying topical steroids. In response to these treatment modalities, two patients were reported to have an improvement in their symptoms (information was not provided for the other two cases). Three patients were reported to have extraoral reactions such as perioral dermatitis, mild lip swelling, and diffuse urticaria. The symptoms of one patient were related to the solder on the headgear's facebow and resolved once the facebow was removed. For the other two cases, the ODAs were removed or changed to nonnickel appliances with resolution of symptoms. In the final case, both intraoral and extraoral reactions were noted, manifesting as gingivitis and lip swelling. Treatment for this patient included removal of the ODAs and change to a nonnickel appliance with a good outcome.

DISCUSSION

Although NA and the placement of nickel-containing ODAs are common in the United States, the relationship between them is controversial. Our survey of orthodontists reveals that reactions to ODAs are very

Table 1 Details of 8 reported cases of presumed adverse reactions to nickel-containing orthodontic appliances*

	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7	Case 8
Known to be nickel-allergic prior to orthodontia	Yes	Yes	Yes	Yes	No	No	No	ND
Age (yr)	14	13	14	22	13	14	52	14
Gender	F	F	F	M	F	M	F	F
Pierced ears	ND	Yes	ND	No	No	ND	Yes	Yes
Nature of reaction	Gingivitis	Perioral dermatitis	Gingivitis, intraoral ulcers	Diffuse urticaria	Slight lip swelling, perioral dermatitis	Lip swelling, gingivitis	Generalized intraoral burning sensation	Slight swelling of buccal mucosa
Treatment	Removed braces, changed to non-nickel	Changed to non-nickel	Removed braces, changed to non-nickel, topical steroids	Removed braces	Removed facebow of headgear	Removed braces, changed to non-nickel	Removed braces, changed to non-nickel bracket, continued use of nickel-titanium wires	Changed to non-nickel
Outcome	ND	Resolved	Resolved	Resolved	Resolved	Resolved	ND	Resolved

*Details for remaining 2 cases not provided from orthodontists completing survey.

ND = No details provided.

uncommon and easily manageable in those affected. In our survey, 10 suspected cases of adverse reactions to nickel-containing ODAs represent a 0.03% prevalence rate. These reactions were mild and primarily intraoral in nature. The nature of the reactions is atypical for ACD commonly seen on the skin. NA as it manifests on mucosal membranes appears to differ from that on intact, keratinized skin. The description of one patient developing diffuse urticaria as a result of ODAs is atypical but allergic contact urticaria to nickel and other metals including aluminum, iridium, platinum, and rhodium has been described.⁷

Some data suggest that ODAs induce nickel hypersensitivity^{10,20} whereas other data proposes that they induce tolerance.^{21–23} However, additional data conclude ODAs neither induce tolerance nor sensitize.²⁴ The timing of orthodontia appliance placement may be important. For example, if orthodontia appliance placement precedes ear piercing, there is a reduced prevalence of NA, whereas placement after ear piercing may result in a higher prevalence.^{21–23,25} However, other data suggest timing is of minimal importance.²⁰

We anticipated that orthodontists are in the advantageous position to identify cases of NA related to ODAs. This survey of Wisconsin orthodontists only identified 10 cases of presumed adverse reactions to nickel-containing ODAs. Because over one-third of orthodontists placed nickel-containing ODAs in NA patients, we expected a higher prevalence of nickel-induced allergic reactions. The orthodontists who completed the survey were experienced, practicing for decades, and treating thousands of patients with nickel-containing appliances. Nearly 30% of orthodontists note body piercings on their patients, suggesting that they are aware of nickel dermatitis and frequently inquire about NA. Referrals for evaluation of NA were equally distributed among allergists, dermatologists, and primary care physicians. It is unclear if this distribution indicates a lack of awareness of the usefulness of a subspecialty consultation or reflects the low prevalence of adverse reactions to ODAs. We found that 50% of orthodontists placed a single intraoral appliance as a trial, indicating they had concern about the possibility of a reaction. Interestingly, three orthodontists performed patch testing by applying appliances to the patient's skin.

Our survey is similar to that performed by Schuster in Germany where orthodontists were asked to record and report allergic reactions to orthodontic metals in the previous 5 years, to document the signs and symptoms and to describe the ensuing treatment. An unspecified number of orthodontists placed a single intraoral appliance as a trial. They concluded that the allergic potential of ODAs is overestimated with a prevalence of 0.23% using study data and reference data from the Hessian Board of Panel Dentists.²⁶

When comparing Schuster's study to our results, there are important differences and similarities. They surveyed 89 orthodontists (with 76% response rate)²⁶ compared with our 220 professionals (only 20% response). The two surveys differed in the time period in which the orthodontist identified any adverse reactions (previous 5 years compared with entire practice). The number of patients represented by this time period was 60,000 in Schuster's study compared with 33,634 in our study. Participant, patient, and practice demographics were not reported by Schuster. They identified 139 cases compared with our 10 cases and the most common adverse reactions were extraoral²⁶ compared with our finding of more common intraoral reactions. The most common treatment approach is changing to nonnickel ODAs. Interestingly, one patient in our study had their brackets changed to nonnickel but nickel-containing wires were continued without incident, suggesting the bracket as the source. Both studies conclude that the prevalence of adverse reactions to nickel-containing ODAs is <1% and orthodontists place single intraoral appliances as a trial. Unique to our study is the report of three orthodontists who performed a "patch test" using nickel-containing ODAs.

The low prevalence of adverse reactions to nickel-containing ODAs reported by both studies is in contrast to the 10–15% prevalence rate of ACD caused by nickel. The following features of the oral environment may account for the low prevalence rate: (1) dilution of nickel by saliva; (2) saliva may form barrier films decreasing sensitization²⁶; (3) IgA antibodies may act to neutralize allergens; (4) the nonkeratinized oral mucosa lacks a keratin layer where proteins may combine with simple chemicals to form allergens²⁷; (5) the oral mucosa contains less Langerhan's cells, which play a key role in contact dermatitis sensitization²⁶; and (6) the extensive vascularization of the oral mucosa prevents prolonged contact with allergens by absorbing and dispersing allergens.²⁷ Levels of nickel in saliva and serum from ODAs have been detected in patients but are not statistically different from controls. These levels do not exceed the average daily intake of nickel or approach toxic levels.²⁸ It is unknown if some or all of these mechanisms are involved, making the oral mucosa more difficult to sensitize.

Limitations for our study include recall bias and a low rate of survey return. The low response rate may support the notion that adverse reactions to nickel-containing ODAs are rare and that those orthodontists who failed to return the survey had not recognized such a reaction or one had not occurred. We are unable to confirm cause and effect relationships between the adverse reactions reported and NA. Rather, the goal of our survey was to characterize if Wisconsin orthodontists have observed potential adverse reactions to

nickel-containing ODAs and how these reactions were managed.

This survey of practicing orthodontists in Wisconsin supports the rare occurrence of adverse reactions to nickel-containing ODAs. If reactions occur, they are managed without difficulty using nonnickel ODAs or removal of the appliances.

REFERENCES

1. Mydlarski PR, Katz AM, Mamelak AJ, et al. Contact dermatitis. In Middleton's Allergy Principles & Practice. Adkinson N F Jr, Yunginger JW, Busse WW, Bochner BS, Holgate ST, and Simons E R (Eds). Philadelphia: Mosby, 1581–1597, 2003.
2. Danish Ministry of the Environment. Statutory Order from the Ministry of the Environment on Prohibition of Sale and on Labelling of Certain Nickel-containing Products No. 854, December 16, 1991.
3. Danish Ministry of the Environment and Energy. Statutory Order from the Ministry of the Environment and Energy on Prohibition of Import and Sale of Certain Nickel-containing Products No. 24, January 14, 2000.
4. European Union Council. Directive 94/27/EC, June 30, 1994.
5. European Union Commission. Directive 2004/96/EC, September 27, 2004.
6. Jensen CS, Lisby S, Baadsgaard O, et al. Decrease in nickel sensitization in a Danish schoolgirl population with ears pierced after implementation of a nickel-exposure regulation. *Br J Dermatol* 146:636–642, 2002.
7. Contact urticaria. In Fisher's Contact Dermatitis. Rietschel RL, and Fowler JF Jr (Eds). Philadelphia: Lippincott Williams & Wilkins, 581–604, 2001.
8. Rietschel RL, and Fowler JF Jr (Eds). Contact dermatitis and other reactions to metals. In Fisher's Contact Dermatitis. Philadelphia: Lippincott Williams & Wilkins, 605–662, 2001.
9. American Association of Orthodontists. Available online at www.braces.org; last accessed Oct. 1, 2005.
10. Bass JK, Fine H, and Cisneros GJ. Nickel hypersensitivity in the orthodontic patient. *Am J Orthod Dentofacial Orthop* 103:280–285, 1993.
11. Rahilly G, and Price N. Nickel allergy and orthodontics. *J Orthod* 30:171–174, 2003.
12. Fors R, and Persson M. Nickel in dental plaque and saliva in patients with and without orthodontic appliances. *Eur J Orthod* 28:292–297, 2006.
13. Jensen CS, Lisby S, Baadsgaard O, et al. Release of nickel ions from stainless steel alloys used in dental braces and their patch test reactivity in nickel-sensitive individuals. *Contact Derm* 48:300–304, 2003.
14. de Silva BD, and Doherty VR. Nickel allergy from orthodontic appliances. *Contact Derm* 42:102–103, 2000.
15. Pigatto PD, and Guzzi G. Systemic contact dermatitis from nickel associated with orthodontic appliances. *Contact Derm* 50:100–101, 2004.
16. Mancuso G, and Berdondini RM. Eyelid dermatitis and conjunctivitis as sole manifestations of allergy to nickel in an orthodontic appliance. *Contact Derm* 46:245, 2002.
17. Temesvari E, and Racz I. Nickel sensitivity from dental prosthesis. *Contact Derm* 18:50–51, 1988.
18. Wilson AG, and Gould DJ. Nickel dermatitis from a dental prosthesis without buccal involvement. *Contact Derm* 21:53, 1989.
19. Veien NK, Borchorst E, Hattel T, et al. Stomatitis or systemically induced contact dermatitis from metal wire in orthodontic materials. *Contact Derm* 30:210–213, 1994.
20. Kalimo K, Mattila L, and Kautiainen H. Nickel allergy and orthodontic treatment. *J Eur Acad Dermatol Venereol* 18:543–545, 2004.
21. Todd DJ, and Burrows D. Nickel allergy in relationship to previous oral and cutaneous nickel contact. *Ulster Med J* 58:168–171, 1989.
22. Kerosuo H, Kullaa A, Kerosuo E, et al. Nickel allergy in adolescents in relation to orthodontic treatment and piercing of ears. *Am J Orthod Dentofacial Orthop* 109:148–154, 1996.
23. Van Hoogstraten IM, Andersen KE, Von Blomberg BM, et al. Reduced frequency of nickel allergy upon oral nickel contact at an early age. *Clin Exp Immunol* 85:441–445, 1991.
24. Menezes LM, Campos LC, Quintao CC, et al. Hypersensitivity to metals in orthodontics. *Am J Orthod Dentofacial Orthop* 126:58–64, 2004.
25. Mortz CG, Lauritsen JM, Bindslev-Jensen C, et al. Nickel sensitization in adolescents and association with ear piercing, use of dental braces and hand eczema. The Odense Adolescence Cohort Study on Atopic Diseases and Dermatitis (TOACS). *Acta Derm Venereol* 82:359–364, 2002.
26. Schuster G, Reichle R, Bauer RR, et al. Allergies induced by orthodontic alloys: Incidence and impact on treatment. Results of a survey in private orthodontic offices in the Federal State of Hesse, Germany. *J Orofac Orthop* 65:48–59, 2004.
27. Rietschel RL, and Fowler JF Jr (Eds). Contact stomatitis and cheilitis. In Fisher's Contact Dermatitis. Philadelphia: Lippincott Williams & Wilkins, 663–685, 2001.
28. Agaoglu G, Arun T, Izgi B, et al. Nickel and chromium levels in the saliva and serum of patients with fixed orthodontic appliances. *Angle Orthod* 71:375–379, 2001. □

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.