Allergic reactions associated with metal alloys in porcelain-fused-to-metal fixed prosthodontic devices—A systematic review

Lauren Levi, DMD[1]/Shlomo Barak, DMD[2]/Joseph Katz, DMD[3]

Objective: To systematically review the allergic reactions associated with metal alloys in porcelain-fused-to-metal (PFM) fixed prosthetic devices. **Method and Materials:** After reviewing the titles and abstracts of the articles as well as removing duplicates, 22 articles were considered relevant. PubMed, Web of Science, ScienceDirect, and Google Scholar from 1970 to 2012 were evaluated, and randomized studies, review articles, case reports, cross-sectional surveys, and abstracts were included. Conference papers and posters were excluded. **Results:** Although reported, allergic reactions to metallic alloys in the context of PFM devices are not well documented. Allergic reactions to high noble and noble metal alloy cores of palladium and gold and to base metal alloys nickel and cobalt in the context of PFM fixed partial dentures (FPDs) are reported. Each type of metal is associated with a different rate of allergic reactions, which may be attributed to the extent of corrosion of the alloy, population exposure, and the biologic environment. Because few studies document allergic reactions to metals that comprise PFM crowns and partial dentures, further research in this field is necessary to determine the frequency and type of reactions elicited. **Conclusion:** Though allergic reactions to metal alloys used in dentistry are well documented, only few articles focus on the correlation between FPDs and metal allergies. Thus, this paper surveys case reports of hypersensitivity reactions linked to FPDs and reviews the current literature on allergic reactions to the metallic elements comprising those devices. *(Quintessence Int 2012;43:871–877)*

Key words: dentistry, fixed partial denture, metal allergy, systematic review

As esthetics become increasingly desired in today's society, many individuals seek a natural smile, motivating clinicians to use porcelain-fused-to-metal (PFM) crowns and fixed partial dentures (FPDs) rather than cast gold crowns. Some might argue, however, that prescribing treatments from a primarily esthetic orientation could compromise the longevity of those treatments.[1] Further, allergic reactions to metal alloys utilized in dental treatments are well documented.[2] Of all metal alloys, nickel allergies are reported to occur the most frequently,[3] affecting 15% of the population receiving treatment.[4] One study conducted in New Zealand revealed that 17.4% of dentists encountered metal allergies in patients.[5] Eight percent of the population is sensitive to cobalt, and 8% is sensitive to chromium.[4] Allergic reactions to other metals—namely, palladium, gold (Fig 1), copper,[6] mercury, tin, platinum, and zinc—are documented, yet their exact prevalence is unclear.[4] Studies also report reactions for multiple elements; for example, cross-reactivity for nickel and palladium is proposed.[4,7] Type IV hypersensitivity reactions to intraoral applications of stainless steel alloys have also been shown.[3] One study examining 296 patients referred to the Norwegian National Dental Biomaterials Adverse Reaction Unit over a 4-year period stated that 11% of patients were referred for adverse reactions to metals in crowns and partial dentures.[2] The most common allergic reactions reported consist of cell-mediated hypersensitivity reactions in the form of contact dermatitis[3] and lichenoid reactions,[8] stomatitis, erythema, swelling,

[1]Resident, Columbia University, New York, New York, USA.

[2]Senior Lecturer, Hillel Yaffe Medical Center, Hadera, Israel.

[2]Professor, Department of Oral and Maxillofacial Diagnostic Sciences, University of Florida College of Dentistry, Gainesville, Florida, USA.

Correspondence: Dr Joseph Katz, Department of Oral and Maxillofacial Diagnostic Sciences, University of Florida College of Dentistry, PO Box 100416, Gainesville, FL 32610. Email: jkatz@dental.ufl.edu

Fig 1 Allergic response to gold in a patient with an FPD.

and pain.[4,9] Mucosal allergies to intraoral metals are rare.[10] Additionally, one study revealed that hypersensitivity reactions in patients with PFM FPDs dissipated upon removal of the prosthesis and replacement with zirconia FPDs.[11]

Several articles discuss cell-mediated hypersensitivity reactions caused by metal alloys in orthodontic wires[10,12] and amalgam restorations placed in the oral cavity,[9] but few focus on the correlation between FPDs and crowns and metal allergic reactions. Thus, this paper surveys case reports of hypersensitivity reactions linked to FPDs, including PFM crowns and partial dentures, and reviews the current literature on allergic reactions to the metallic elements comprising those devices.

This paper divides allergic reactions to FPDs based on the type of metal core. PFM crowns can be categorized using the ADA and Identalloy Classification System, which classifies according to the composition of the metal alloy.[1] High noble metals consist of greater than or equal to 60% noble metals (noble metals include gold, palladium, and platinum) and greater than or equal to 40% gold. Meanwhile, noble alloys contain greater than or equal to 25% noble metals, and those in the third group, base metals, are composed of less than 25% noble metals.

Allergenicity has been attributed to an element's ability to corrode, which depends upon the alloy phase structure, alloy composition, and the biologic environment to which it is subjected.[4,10] With respect to composition, alloys composed of multiple phases often release elements at a greater rate. In terms of the element's ability to corrode, previous literature suggests that elements from alloys are released into the oral cavity[4] and that the temperature and pH alter their release.[10]

The biologic environment to which alloys are subjected can affect allergenicity by influencing the prevalence of the elements in the oral cavity. Nickel alloys, for example, release more ions from orthodontic wires under conditions of lower pH and higher temperatures.[10] Further, Setcos et al[10] revealed that comparing saliva of individuals with nickel orthodontic wires with those without nickel orthodontic wires showed no significant increase in nickel salivary levels after 3 weeks of placement. The study proposes numerous potential explanations: the constant elemental dilution and rinsing action of saliva leads metals to be swallowed; the lack of thickness of the stratum corneum limits the availability of carrier proteins to develop antigens by joining with metallic haptens; the high vascularity causes allergens to scatter quickly in the oral environment; and metals might result in immunosuppression.[10] In contrast, elements not constantly rinsed by saliva could reach higher levels in the oral environment. PFM crowns and FPDs with metal collars placed

Table 1 Search history for literature review on allergic reactions to metals in PFM devices

Search history	Total hits for articles published between 1970 and 2012
Dental allergy and fixed prostheses	497
Hypersensitivity and fixed prostheses	879
Allergy and fixed prosthodontic denture	153
Hypersensitivity and fixed prosthodontic denture	124
Allergy and dental crown	929
Hypersensitivity and dental crown	867
Porcelain fused metal prosthodontic allergy	72
Allergy and fixed dental prosthetic device	553

PFM, porcelain fused to metal.

subgingivally might result in high levels of metal ions because they are not exposed to the washing action of saliva. Wataha[4] states that copper levels of 10 µg/gram negatively affect gingival epithelial cells, yet ingesting 10 µg/gram is believed to be innocuous.[4]

Elemental dosage may appear to play a role due to the diffuse boundary between allergenicity and toxicity. This paper, however, will focus on allergic reactions to metal alloys in the context of PFM crowns and partial dentures. While allergic reactions are considered to occur independently of an element's dosage, toxicity depends on dosage, and therefore, toxicity and allergenicity may be difficult to distinguish. This is because allergic reactions traditionally result in inflammation by activating immune cells; still, metals can affect the immune system without classically posing as metal-protein antigen complexes and influencing immune cells.[4]

The purpose of the present study is to review the different types of alloy cores and case studies reflecting their ability to elicit allergic reactions.

METHODS

Data sources

A literature search of PubMed, Web of Science, ScienceDirect, and Google Scholar was performed for the years 1970 to 2012 to isolate case reports and studies discussing allergic reactions to metals in the context of PFM FPDs. Only articles published in English were reviewed. The search terms and hits after duplicate references were discarded are included in Table 1.

Study selection

Randomized studies, review articles, case reports, cross-sectional surveys, and abstracts published in peer-reviewed journals were screened for inclusion. Conference papers and posters were excluded because of the potentially less stringent review process. Only review articles discussing allergic reactions to metals were included; thus, articles discussing allergic reactions to provisional restorations and nonmetallic elements in removable prosthodontic devices were excluded. Additionally, only case reports discussing metals found in PFM devices were included.

Data extraction

After reviewing the titles and abstracts of the articles, as well as removing duplicates and redundancies, 22 articles were considered relevant. These included 10 case reports, 6 review articles, 4 cross-sectional studies, 1 hypothesis, and 1 case-controlled study. In addition to direct searches, reference lists in articles cited were also reviewed to identify additional information.

RESULTS AND DISCUSSION

High noble and noble metal alloy cores

Few studies document cases of allergic reactions to noble metals in the context of PFM FPDs. As stated earlier, allergic reactions to palladium alone are infrequent and often occur along with base metals such as nickel,[7] chromium, and cobalt because of cross-reactivity.[13] Additionally, although rare, allergic reactions to gold have been reported.[4,14]

Intraoral manifestations of palladium contact sensitivity include blisters, papules, erythema, gingival bleeding, and ulcers. Symptoms also include oral lichenoid lesions, toothache, oral lichen planus, burning mouth syndrome, metallic taste, facial pain, glossitis, xerostomia, and pain in the jaw. Extraorally, signs of intraoral palladium sensitivity consist of contact dermatitis, eczema, chronic urticaria, chronic fatigue syndrome, vertigo, sleep disturbances, depression, headache, and even porphyria.[13]

Clinical case reports associated with PFM FPD palladium-based alloys. Case studies of palladium allergic reactions in the context of PFM FPDs report reactions ranging from contact stomatitis to hypersensitivity neuropathy. Mizoguchi et al[15] reported linear lichen planus along with pruritus along the mandible as well as a peculiar mouth sensation. The patient had crowns and a partial denture placed consisting of palladium-silver-gold or nickel-chromium alloys. Patch testing revealed positive allergic responses to palladium and platinum. Contact dermatitis was also reported at the palladium patch test site. The symptoms resolved after removal of the dental alloys.[15] Additionally, one case report conveyed a patient presenting with eosinophilia and complaining of burning mouth syndrome possibly related to placement of a palladium-based alloy PFM FPD and placement of three titanium implants. The patient's patch test indicated a positive allergic response to palladium and cadmium, yet the allergic responses were negative to nickel. Upon removal of the palladium crowns and replacement of amalgam underneath the crowns, the burning mouth syndrome symptoms did not resolve but resolution of the persistent eosinophilia was noted, forcing further questioning of the relationship of burning mouth syndrome and palladium allergic reactions.[16]

Moreover, Garau et al[13] revealed an allergic reaction associated with cementation of a PFM FPD composed of gold palladium. The patient complained of xerostomia, burning, pruritus, and swelling of the upper lip within days of cementation; the patient then experienced mucositis and periodontal probing depths of 3 to 4 mm adjacent to the FPD 1 month after placement. Patch testing conveyed the patient's positive reaction to palladium chloride, and subsequent removal resulted in involution of symptoms within 1 month.[13]

In addition to local reactions, palladium allergic reactions have manifested systemically: Hansen and West[6] reported that a PFM FPD composed of VITA porcelain (79% palladium, 2% gold, and 19% copper) elicited hypersensitivity neuropathy 4 hours after placement due to an allergic reaction to Option (79% palladium, 2% gold, and 19% copper metal alloy). Symptoms ranged from initial gingival edema and burning adjacent to the FPD, maxillary perioral urticaria, and cheek edema to nasal congestion, pedal edema, generalized muscular weakness, decreased urinary output, and blurred vision. Hansen and West[6] also mentioned systemic manifestations such as muscle pedoacral spasms, muscle cramps and weakness, paresthesia, burning and tingling with chronic pedal swelling, and episodic discoloration. Patch testing revealed that the patient tested positively to Ticonium, Option, and Rexilium, although the reaction manifested 48 hours after testing. Additionally, the patient reported numbness in the arm that was tested. After removal of the prosthesis, the patient's symptoms subsided.[6]

Clinical case reports associated with PFM FPD gold-based alloys. Although rare, hypersensitivity reactions to gold alloys in FPDs have been documented.[14] Shephard et al[17] revealed that a patient formerly sensitized to gold earrings reported itching and burning pain and oral tissue ulceration adjacent to a gold restoration.[17] Patch testing

revealed the patient's allergy to gold. Furthermore, Wisenfeld et al[18] reported formation of an ulcer on adjacent mucosa following placement of a gold crown on a patient who tested positively to a patch test to gold chloride.[18]

Lazarov et al[14] reported on orofacial granulomatosis associated with placement of two maxillary gold crowns. Symptoms of orofacial granulomatosis included upper lip swelling and erythema, and the patient tested positive to gold sodium thiosulphate (2%). The study states that orofacial granulomatosis has also been reported with cobalt allergies. Additionally, Lazarov et al[14] stated that the persistence of orofacial granulomatosis as well as the appearance of noncaseating granulomas were consistent with a type IV hypersensitivity reaction. It is possible that the response occurred because of an allergic contact reaction to gold or because the gold provoked a granulomatous contact allergic reaction.[14]

Base metal alloy cores

Among base metals, allergic reactions to nickel, cobalt, and chromium have been shown.[3,19] Nickel-chromium (Ni-Cr) alloys consist of between 69% and 81% nickel. Cobalt-chromium (Co-Cr) alloys are composed of 60% to 65% cobalt, 27% to 30% chromium, 5% to 6% molybdenum, and less than 1% nickel. Stainless steel alloys contain 18% chromium and 8% nickel.[3] Although many refer to nickel, chromium, and cobalt as inoxidizable, allergic or toxic reactions to these three base metal alloys may occur because of corrosion. Hildebrand et al[3] states that Ni-Cr, Co-Cr, and stainless steel alloy exposure correlates with type IV hypersensitivity reactions in the form of contact dermatitis.[3] In one study of individuals with previous dermatologic conditions, 9.6% exhibited type IV hypersensitivity reactions to nickel, 9.3% exhibited hypersensitivity to chromium, and 6% exhibited contact dermatitis to cobalt. Nonetheless, of the general population, Hildebrand et al[3] reported nickel contact dermatitis reactions in 4.2% of individuals and chromium contact dermatitis reactions in 1.7% of individuals. Not limited to the oral cavity, these reactions also resulted from occupational and environmental exposure.[3]

In most cases, allergic reactions and sensitivity to nickel alloys happened in connection with the insertion of nickel orthodontic wires. Intraoral manifestations of allergic reactions in these cases include edema, perioral stomatitis, and gingivitis, whereas extraoral manifestations consist of eczematous rashes.[10] Additionally, one study conveyed that when comparing individuals with oral diseases and prosthetic devices with those with oral diseases without prosthetic devices, a higher frequency of positive allergic responses was found in those with prosthetic devices. Furthermore, the study found that individuals with lichen planus exhibited the highest frequency of positive patch tests, and the most frequent allergens were nickel, cobalt, and chromium.[20] The few documented reports of allergic reactions to base metals comprising FPDs indicate that the symptoms of hypersensitivity reactions range from recurrent hypersensitive skin reactions[21] to allergic palmoplantar pustolosis (PPP).[22]

While healing may occur after prostheses withdrawal, sensitivity can remain. Upon review of 149 cases of nickel, chromium, and/or cobalt exposure, 127 patients exhibited healing after their prostheses were removed (type of dental prostheses not stated). Despite removal, 76% to 93% of individuals with reported nickel sensitivities had continued sensitivity for years.[3]

Clinical case reports associated with PFM FPD nickel-based alloys. Although nickel allergies are well documented, few studies isolate nickel allergies in the context of FPDs. Lamster et al[23] reported loss of alveolar bone adjacent to PFM devices high in nickel 18 months after crown placement in two females who tested positively for nickel allergy in a skin patch test. Additionally, Straus and Eggleston[24] reported IgA nephropathy associated with nickel-alloy base dental crown placement. The patient exhibited hematuria, proteinuria, and hypertension followed by nephrotic-range proteinuria, which increased with greater nickel placement and diminished with subsequent removal of the nickel crowns. Strauss and Eggleston[24] suggested that this case might signify nickel-induced sensitization and IgA glomerulopathy. On the contrary, Spiechowicz et al[21] followed patients

over a 15-year period and found that those with histories of nickel hypersensitive skin reactions failed to exhibit mucosal or systemic reactions following nickel-alloy crown or FPD placement containing 66% nickel.

Clinical case reports associated with PFM FPD cobalt-based alloys. Song et al[22] documented allergic PPP elicited by cobalt-chromium alloy cast dental crowns consisting of 63.3% cobalt, 30% chromium, 5% molybdenum, 1% silicon, 0.3% carbon, and 0.2% manganese. Allergic PPP manifested in the form of several pustules with surrounding erythema and scaling and fissures of the palmar and plantar surfaces. No intraoral symptoms were noted, and the patient tested positively for cobalt chloride allergy through a patch test and drug lymphocyte stimulation test. The symptoms disappeared within 3 weeks of crown removal.[22]

CONCLUSION

Although reported, allergic reactions to metallic alloys in the context of PFM FPDs are not well documented. Allergic reactions to high noble and noble metal alloy cores of palladium and gold and to base metal alloys nickel and cobalt in the context of PFM FPDs are reported. Each type of metal is associated with a different rate of allergic reaction, which may be attributed to the extent of corrosion of the alloy, population exposure,[4] and the biologic environment. Nickel allergies occur most commonly, and this might be due to the frequency of nickel alloys in jewelry. Conversely, gold allergies and hypersensitivity to gold are purportedly rarely seen, despite the metal's common use in jewelry, which is likely due to the metal's low corrosion rates.[4] As for manifestations, noble metal sensitivities range from contact dermatitis[13] to hypersensitivity neuropathy[6] and orofacial granulomatosis.[14] Meanwhile, base metals may cause allergic reactions in a variety of forms including IgA nephropathy[24] and PPP.[22]

The dearth of knowledge in this area calls for more research, yet as revealed by the current literature, clinicians should still practice caution in using metal alloys. Because few studies document allergic reactions to metals that comprise PFM crowns and partial dentures, further research in this field is necessary to determine frequency and type of reactions elicited. With what is currently available, clinicians should still consider the biocompatibility and corrosion rates of elements when choosing metal alloys.

REFERENCES

1. Shillingburg HT, Hobo S, Whitsett LD. Fundamentals of Fixed Prosthodontics. Chicago: Quintessence, 1997.
2. Vamnes JS, Lygre GB, Grönningsaeter AG, Gjerdent NR. Four years of clinical experience with an adverse reaction unit for dental biomaterials. Community Dent Oral Epidemiol 2004;32:150–157.
3. Hildebrand HF, Vernon C, Martin P. Nickel, chromium, cobalt dental alloys and allergic reactions: An overview. Biomaterials 1989;10:545–548.
4. Wataha J. Biocompatibility of dental casting alloys: A review. J Prosthet Dent 2000;83:223–234.
5. Zhou J, Paul A, Bennani V, Thomson WM, Firth NA. New Zealand dental practitioners' experience of patient allergies to dental alloys used for prosthodontics. N Z Dent J 2010;106:55–60.
6. Hansen PA, West LH. Allergic reaction following insertion of a Pd-Cu-Au fixed partial denture: A clinical report. J Prosthodont 1997;6:144–148.
7. Faurschou A, Menné T, Johansen JD, Thyssen JP. Metal allergen of the 21st century—A review on exposure, epidemiology and clinical manifestations of palladium allergy. Contact Dermatitis 2011;64:185–195.
8. Tosti A, Piraccini BM, Peluso AM. Contact and irritant stomatitis. Semin Cutan Med Surg 1997;16:314–319.
9. Raap U, Stiesch M, Reh H, Kapp A, Werfel T. Investigation of contact allergy to dental metals in 206 patients. Contact Dermatitis 2009;60:339–343.
10. Setcos, JC, Babaei-Mahani A, Di Silvio L, Mjör IA, Wilson NHF. The safety of nickel containing dental alloys. Dent Mater 2006;22:1163–1168.
11. Gökçen-Röhlig B, Saruhanoglu A, Cifter ED, Evlioglu G. Applicability of zirconia dental prostheses for metal allergy patients. Int J Prosthodont 2010;23:562–565.

12. Lu Y, Chen W, Ke W, Wu S. Nickel-based (Ni-Cr and Ni-Cr-Be) alloys used in dental restorations may be a potential cause for immune-mediated hypersensitivity. Med Hypotheses 2009;73:716–717.
13. Garau V, Masala MG, Cortis MC, Pittau R. Contact stomatitis due to palladium in dental alloys: A clinical report. J Prosthet Dent 2005;93:318–320.
14. Lazarov A, Kidron D, Tulchinsky Z, Minkow B. Contact orofacial granulomatosis caused by delayed hypersensitivity to gold and mercury. J Am Acad Dermatol 2003;49:1117–1120.
15. Mizoguchi S, Setoyama M, Kanzaki T. Linear lichen planus in the region of the mandibular nerve caused by an allergy to palladium in dental materials. Dermatol 1998;196:268–270.
16. Pigatto PD, Feilzer AJ, Valentine-Thon E, Zerboni R, Guzzi G. Burning mouth syndrome associated with palladium allergy? Eur J Dermatol 2008;18:356–357.
17. Shephard FE, Moon PC, Grant GC, Fretwell LD. Allergic contact stomatitis from a gold alloy—Fixed partial denture. J Am Dent Assoc 1983;106:198–199.
18. Wisenfeld D, Ferguson MM, Forsyth A, MacDonald G. Allergy to dental gold. Oral Surg Oral Pathol Oral Med 1984;57:158–160.
19. Kelly JR, Rose TC. Non-precious alloys for use in fixed prosthodontics: A literature review. J Prosthet Dent 1983;49:363–370.
20. Mehulić M, Kos P, Komar D, Katunarić M. Expression of contact allergy in undergoing prosthodontic therapy patients with oral diseases. Minerva Stomatol 2005;54:303–309.
21. Spiechowicz E, Glantz PO, Axell T, Grochowski P. A long-term follow-up of allergy to nickel among fixed prostheses wearers. Eur J Prosthodont Restor Dent 1999;7:41–44.
22. Song H, Yin W, Ma Q. Allergic palmoplantar pustulosis caused by cobalt in cast dental crowns: A case report. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2011;111:e8–e10.
23. Lamster IB, Kalfus DI, Steigerwald PJ, Chasens AJ. Rapid loss of alveolar bone associated with non-precious alloy crowns in two patients with nickel hypersensitivity. J Periodontol 1987;58:486–492.
24. Strauss FG, Eggleston DW. IgA nephropathy associated with dental nickel alloy sensitization. Am J Nephrol 1985;5:395–397.