# Metal Allergy and Contact Urticaria

# 40

Niels H. Bennike and Majken H. Foss-Skiftesvik

## 40.1 Introduction

Although an abundance of different metals exists, most humans are only exposed to a minority of these, and only some cause sensitization. As opposed to delayed type IV hypersensitivity reactions to metals, which are well documented [1], cutaneous type I hypersensitivity reactions are rarely reported. In this chapter, we briefly describe clinical and epidemiological features of contact urticaria and review the existing literature on contact urticaria caused by metals.

## 40.2 Contact Urticaria

Contact urticaria is defined by a cutaneous wheal and flare reaction after external contact with an eliciting agent. The reaction usually appears within minutes and clears completely within hours leaving no residual signs of inflammation or scarring [2].

Contact urticaria can be classified as either non-immunological (irritant) or immunological (allergic), according to the underlying mechanism. Immunological contact urticaria results from a type I hypersensitivity reaction mediated by pre-formed IgE antibodies and mast cells. In contrast, non-immunologic contact urticaria is not IgE mediated; however, the exact pathogenesis of this disease entity is not fully understood. For some of the classic urticariogens, such as dimethyl sulfoxide, induction of mast cell degranulation and release of epidermal prostaglandins are believed to be caused by local blood vessel damage at the site of contact [3]. However, each trigger substance presumably has its own mechanism of action.

Clinical manifestations of immunological contact urticaria have the potential to extend beyond the point of contact with the noxious agent. Generalized urticaria, along with involvement of respiratory and gastrointestinal organs, may develop with the potential to culminate in anaphylactic shock (Table 40.1) [3]. This potential for multisystem involvement led to the definition of the term contact urticaria syndrome, introduced

**Table 40.1** Diseases involved in the contact urticaria syndrome (Reproduced with permission from [3])

| | |
|---|---|
| Stage 1 | Contact urticaria<br>Immediate contact dermatitis<br>Nonspecific symptoms (itching, tingling, burning sensation) |
| Stage 2 | Generalized urticaria |
| Stage 3 | Bronchial asthma<br>Rhino-conjunctivitis<br>Orolaryngeal symptoms<br>Gastrointestinal dysfunction |
| Stage 4 | Anaphylaxis<br>Anaphylactoid reaction |

N.H. Bennike (✉) • M.H. Foss-Skiftesvik
Department of Dermatology and Allergy,
Copenhagen University Hospital Herlev-Gentofte,
Hellerup, 2900, Denmark
e-mail: niels.hoejsager.bennike@regionh.dk;
majken.gabriel.hougaard@regionh.dk


J.K. Chen, J.P. Thyssen (eds.), *Metal Allergy*, https://doi.org/10.1007/978-3-319-58503-1_40

by Maibach and Johnson in 1975 [4]. Figure 40.1 summarizes a proposed algorithm for diagnosing immediate contact hypersensitivity reactions, including contact urticaria suspected to be caused by metals. Life-threatening anaphylactic reactions have been reported during diagnostic skin testing with metals [5, 6] and, in general, testing should only be performed if resuscitation equipment and trained personnel are readily available.

Epidemiological data regarding contact urticaria are sparse. A frequency of 1–3% is reported in the general population, while the prevalence in healthcare workers in Europe varies from 5 to 10% [3]. In Australian data, 8.3% of patients with occupational skin disease suffered from contact urticaria, mainly due to latex, food sources, and ammonium persulfate [7]. A typical wheal and flare reaction is easily diagnosed by the clinician, but the reaction after exposure to diluted classical urticariogens can be limited to erythema or even pruritus as the only evident symptom [8], thereby making diagnostics more difficult. Hence some degree of underdiagnosing is believed to occur, especially regarding non-immunological contact urticaria.

## 40.3 Contact Urticaria and Nickel

Nickel belongs to the group of transitional metals. With its widespread use in products such as alloys, coins, cosmetics, jewelry, orthopedic implants, and household utensils, skin exposure is common both in an occupational and nonoccupational setting. Although nickel is a frequent and well-established cause of delayed type IV hypersensitivity, nickel-induced type I hypersensitivity eliciting an urticarial response has rarely been reported. The mechanism behind the immediate contact inflammatory reactions to nickel is not fully understood.

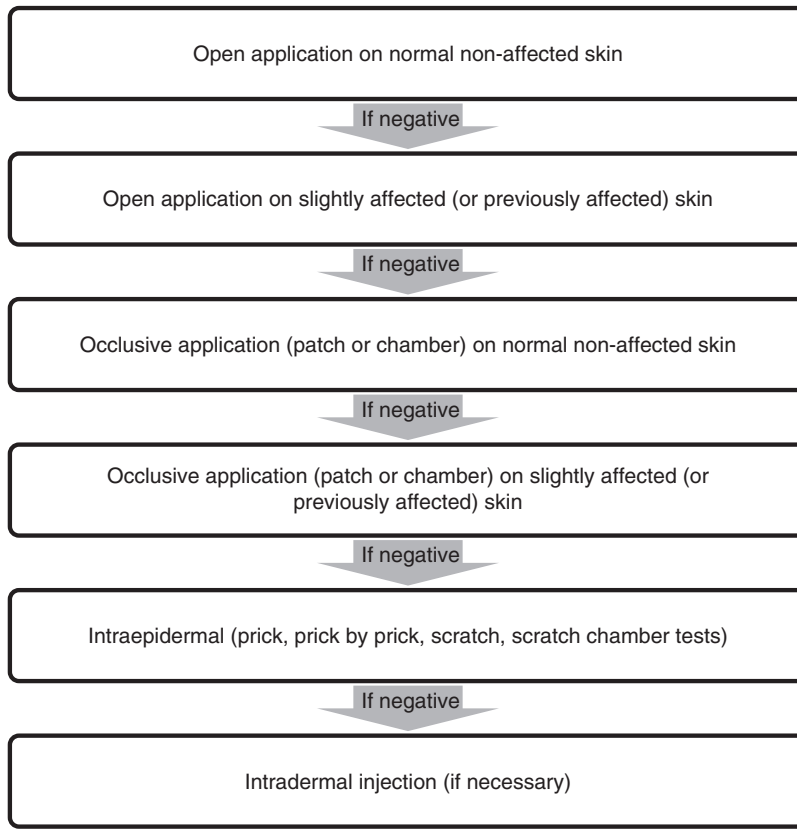


**Fig. 40.1** Proposed algorithm for the diagnosis of immediate skin contact reactions (Reproduced with permission from [3])

Initially, it was thought that nickel may act as a mast cell discharger on a non-immunological basis [9]. In one of the more recently published case reports discussed below, a positive radioallergosorbent test (RAST) indicated that the observed urticarial reaction to nickel was, at least partly, IgE mediated [10]. Nevertheless, the reported case was the only patient in a 15-year period with a positive RAST to nickel among nickel allergic patients at this facility, and the absolute titer was relatively low. The frequency of contact urticaria caused by nickel in the general population is unknown. In a recent study of 69 patients with positive patch tests to nickel, 24.6% had a history of urticarial symptoms [11]. The few published cases on contact urticaria caused by nickel include individuals with both occupational and nonoccupational exposure (see Table 40.2).

Osmundsen [12] was the first to report two cases of contact urticaria caused by nickel exposure. The first patient, a 30-year-old female cleaner, experienced immediate itching and burning of her palms and fingertips followed shortly after by erythema and edema when handling a bucket with a metal handle. Standard patch testing with nickel showed a ++ reaction, while

**Table 40.2** Case reports on contact urticaria caused by nickel

| Author | Patient(s) | Exposures | Diagnostic tests | Results |
|---|---|---|---|---|
| Osmundsen (1980) [12] | 30 yo female | Metal handle on plastic bucket | Both patients:<br>20-min patch test $NiSO_4$ 2.5%<br>CPT $NiSO_4$ 2.5% | Both patients:<br>20-min patch test on normal skin negative. CPT positive for urticaria after 20 min |
| | 19 yo female | Jewelry | | |
| Malo (1982) [13] | 28 yo male | Metal plating factory worker | SPT $NiSO_4$ 1% | SPT positive |
| Tosti (1986) [14] | 24 yo female | Surgical tools, jewelry | SPT $NiSO_4$ 1%<br>Standard patch test $NiSO_4$ 2.5%<br>Open patch test $NiSO_4$ 5% | SPT positive after 3 min<br>Patch test positive<br>Open patch test positive after 24 h |
| Valsecchi (1987) [15] | 59 yo female | Jewelry | Standard patch test $NiSO_4$<br>30 min patch test $NiSO_4$ 5% | Standard patch test positive (+++)<br>30-min patch test positive for urticaria |
| Estlander (1993) [10] | 27 yo female | Manual grinding of metal casts, jewelry | Standard patch test $NiSO_4$ 2.5%<br>SPT $NiSO_4$ 0.1% and 1%<br>Scratch chamber test $NiSO_4$ 0.1% and 1%<br>1-h open test $NiSO_4$ 1%<br>Specific IgE (RAST) for $NiSO_4$ | Standard patch test positive<br>SPT 1% and scratch chamber test 1% both positive for urticaria<br>1-h open test positive for urticaria<br>Increased specific IgE for $NiSO_4$ |
| Helgesen (1997) [26] | 19 yo female | Coins, doorknobs, bannisters | SPT $NiSO_4$ 2.5%<br>Patch test (open and closed) $NiSO_4$ 0.01%, 0.1%, and 1%<br>Aluminum Finn® chamber<br>Aluminum powder in pet | SPT $NiSO_4$ 2.5% positive<br>Open patch test positive on arm at 10 min to $NiSO_4$ 0.1% and 1%, negative on back<br>Closed patch test positive on arm and back after 1 h and 2 h to $NiSO_4$ 0.1% and 1%<br>Aluminum chamber positive at 2 h on arm and back<br>Aluminum powder positive at 1 h on arm and back |
| Walsh (2010) [16] | 38 yo female | Dental procedures and cutlery | 20 min patch test $NiSO_4$ 1%, 3%, and 5% | All patch tests positive for urticaria after 20 min |

*CPT* chamber prick test, *SPT* skin prick test, *yo* year-old

20-min patch testing with 2.5% nickel sulfate on normal skin of the forearm was negative. A chamber prick test with 2.5% nickel sulfate elicited a strong urticarial reaction after 20 min. A dimethylglyoxime test of the metal handle was strongly positive for nickel.

The second patient, a 19-year-old female, experienced immediate swelling and redness of her earlobes after applying ear clips. Similarly to the first patient, a 20-min patch test with 2.5% nickel sulfate on normal skin was negative, while a positive chamber prick test was observed. The patient tested negative to standard patch testing with nickel. As negative controls, five patients with a positive 48-h patch test to nickel and three patients with chronic urticaria were tested with chamber prick test with nickel sulfate 2.5%. No immediate reactions were observed.

Malo et al. [13] described a 28-year-old man working at a metal plating factory. A year after nickel sulfate was introduced in the electroplating process at the facility, the patient developed an urticarial rash on his arms and legs. The rash was only present when the patient was at work and cleared within a few hours after leaving work. Later, the patient also developed asthmatic symptoms. Skin prick testing with 1% nickel sulfate gave a positive reaction, while eight control subjects showed no positive reactions. When the patient was tested with a specific inhalation challenge with nickel sulfate, he developed a bronchial response suggestive of asthma.

Tosti et al. [14] described a 24-year-old woman who at 13 years of age, following an appendectomy, developed an urticarial reaction and postoperative peritonitis. She had previously noticed immediate redness and swelling after contact with jewelry. As no evidence of antibiotic hypersensitivity existed, it was suspected that other hypersensitivity reactions could possibly explain the observed postoperative complications. A skin prick test with 1% nickel sulfate was positive after 3 min. A standard patch test also showed a positive ++ reaction to nickel, and an open patch test with 5% nickel sulfate gave a positive reaction after 24 h. The authors mentioned nickel-plated cannulas as a possible relevant exposure; however, no further testing was reported.

In another case report, Valsecchi and Cainelli [15] describe a 59-year-old woman, who had been suffering from unspecified lesions on the hands and ears for 6 months. The lesions on the hands changed during the day. She claimed that the lesions on her ears and left wrist were caused by contact with jewelry. The patient was patch tested with standard contact allergens and had a positive +++ reaction to nickel sulfate at 48 and 96 h. A 30-min patch test with 5% nickel sulfate on the forearm gave a strong urticarial reaction mimicking the reaction described by the patient.

Estlander et al. [10] described a 27-year-old woman suffering from nickel-induced allergic contact dermatitis. After working with manual grinding of metal casts for 2 years, she developed symptoms of contact urticaria, rhinitis, and asthma at work. The symptoms cleared completely during weekends and holidays. Standard patch testing showed a positive reaction to 2.5% nickel sulfate. The patient also had positive reactions to a skin prick test and a scratch chamber test with 1% nickel sulfate. An open patch test with the same nickel solution elicited an urticarial reaction on the volar forearm after 45 min. Specific IgE for nickel was evaluated by RAST and was slightly elevated. The patient had a nasal provocation test and a specific inhalation challenge performed with nickel sulfate, and a nasal and bronchial response was elicited within minutes.

In 2010, Walsh et al. [16] described a 38-year-old atopic woman with a history of reacting to dental procedures since childhood. Immediately after exposure to dental instruments, she would develop pain and oral swelling. She also suffered from immediate pain and pruritus of the palms, followed by swelling and erythema within an hour after contact with cutlery. Furthermore, the patient had experienced immediate urticarial symptoms during venesection. When patch tested with nickel sulfate at 1%, 3%, and 5% concentrations on the volar side of the forearm, the patient immediately complained of discomfort under the chamber containing the 5% solution and

developed an urticarial reaction after 20 min at all three test sites.

## 40.4 Contact Urticaria and Chromium

The French chemist Louis Nicolas Vauquelin discovered chromium in 1797. Chromium, belonging to the group of transitional metals, is among the most commonly found metals in the Earth's crust and has found wide applications in areas such as electroplating processes, metal alloys, tanning of leather, cement, paint, and production of chromate salts. Chromium metal is non-allergenic; however, several chromium salts can cause irritation and allergic contact dermatitis [17]. Previously, occupational exposure to chromium in cement was a common cause of contact allergy due to a high content of hexavalent chromium. International regulations of the allowed content of hexavalent chromium in cement have changed the epidemiology of chromium sensitization within European nations. Today, leather products are responsible for the main exposure to chromium [18], where it is estimated that up to 90% of leather produced globally is tanned using chromium [19].

Although chromate is a common cause of delayed hypersensitivity and allergic contact dermatitis, the literature on contact urticaria caused by exposure to chromate is sparse. In 1993, Pizzino [20] described a case of possible contact urticaria caused by exposure to chromate in a 26-year-old man working at a facility producing pipes that were electroplated with chromate. The patient would hose down pipes that had been in open baths containing chromic and sulfuric acids resulting in a mixture of water and chemicals splashing onto his skin. His protective equipment consisted of a cloth apron and respirator. The patient initially developed eczema on his hands and arms, followed by an urticarial rash on most of the body including his face. The urticaria persisted for more than 1 year, where the patient was still exposed to chromate at work. Initial diagnostic workup of the patient showed a positive standard patch test to chromate (++). The patient was further extensively evaluated for other causes of chronic urticaria, but his lesions did not resolve until several months after he was completely withdrawn from occupational chromate exposure.

## 40.5 Contact Urticaria and Cobalt

Cobalt is a hard, silver-gray metal belonging to the group of transitional metals. Cobalt is mainly a by-product from nickel and copper mining. Cobalt is utilized in the production of hard metal alloys, diamond tooling, dyes (blue pigment), magnets, and electronics [21]. Contact allergy to cobalt chloride is common, often associated with concomitant patch test reactivity to nickel or chromate. The frequency of cutaneous type I hypersensitivity to cobalt is unknown, and only a few case reports have been published [6, 22, 23], including a case of anaphylaxis [6]. It has been suggested that cobalt chloride causes contact urticaria through a non-immunological mechanism by inducing the release of vasoactive amines from mast cells [22].

Smith et al. [22] described a 20-year-old man, suffering from X-linked ichthyosis, who experienced contact urticaria following a provocative sweat test. The patient was painted with a mixture of cobalt chloride 10% dissolved in 95% isopropyl alcohol as a color indicator on the neck, arms, trunk, and legs. Seconds after application, the patient noted a stinging sensation in the painted areas, and after 5 min, urticaria developed in the involved areas above the waist. As part of the diagnostic workup to further study the urticaria-producing effect of cobalt chloride, 36 control subjects were tested. A 9-year-old girl developed similar urticarial lesions within minutes after application of the cobalt chloride solution, with the reaction subsiding within 30 min. No skin prick tests or patch test results were reported.

Krecisz et al. [6] reported a 39-year-old nonatopic woman employed as a ceramics decorator. After 3 months of work, the patient developed eczema on the back of her hands and forearms. Subsequently, after continuing work for 5 years,

the patient also developed generalized urticaria, with facial angioedema and general fatigue after working with a blue paint containing cobalt chloride. As the patient was transferred to a different work area, her symptoms disappeared, and she did not have a diagnostic workup performed until 2 years later. Standard patch testing revealed contact allergy (+++) to both nickel sulfate and cobalt chloride. A skin prick test was positive for cobalt chloride (0.1 and 1 mg/mL) only, and cobalt-specific IgE was elevated at 2.97 IU/mL. The patient had a challenge test performed, in which she painted pottery using the blue cobalt-containing paint from her previous workplace. After 30 min, the patient developed urticarial lesions on her hands and forearms, followed by facial angioedema, and the test was regarded positive. Although the exposure was stopped, the patient developed an anaphylactic reaction with hypotension and tachycardia and was successfully treated with intravenous corticosteroids.

Bagnato et al. [23] described a case of contact urticaria to cobalt in a 42-year-old man following a blue-colored tattoo. However, the patient did not develop any urticarial symptoms until 2 months after the tattoo was made, and no test to diagnose immediate cutaneous hypersensitivity was reported.

## 40.6 Contact Urticaria and Aluminum

Aluminum and its salts are rarely reported to cause contact allergy, especially considering the common and widespread exposure in various consumer products including antiperspirants and sunscreens along with medical preparations. However, the diagnosis of type IV hypersensitivity to aluminum is complicated with regard to choosing the optimal aluminum test compound and concentration [24]. Recent attention on cutaneous reactions to aluminum has focused on type IV allergic reactions in relation to administration of injectable vaccines where aluminum salts are used as adjuvants. Up to 1% of children develop vaccination granulomas following injection of aluminum-adsorbed vaccines, and of these, 77–95% develop contact allergy to aluminum [25]. The frequency of cutaneous type I hypersensitivity reactions to aluminum is unknown.

Helgesen and Austad described the only case of contact urticaria to aluminum [26]. A 19-year-old woman reported experiencing a burning sensation and pain within minutes after contact with metal objects such as coins, doorknobs, and bannisters. Shortly after, vesicles and bullae would appear, developing into ulcerations and erosions on the subsequent day. The patient had a positive skin prick test to nickel sulfate and an immediate urticarial reaction to both open and closed patch tests with nickel on the forearm. When tested with an empty aluminum Finn® chamber, erythema and infiltration appeared after 2 h. Applying pure aluminum powder in petrolatum to the skin resulted in an immediate inflammatory reaction after 1 h.

## 40.7 Platinum Group Elements

The platinum group elements (PGEs) include the metals platinum, iridium, palladium, rhodium, ruthenium, and osmium. Unique properties including high melting points, corrosion resistance, and catalytic qualities make PGEs valuable in many industries. All PGEs are rare elements of the Earth's crust. Delayed contact hypersensitivity to PGEs is presumably not as common as type I hypersensitivity, especially in an occupational setting: In a catalyst production facility where 153 workers were evaluated for contact hypersensitivity to PGEs, two workers (1.3%) had an urticarial reaction 25 min after skin prick testing with hexachloroplatinic acid, which was similar to the frequency of type IV hypersensitivity to PGE salts among the workers. In total, 14.4% of the workers had a positive skin prick test to any of the PGE salts tested with concentrations ranging from $10^{-8}$ to $10^{-2}$ mol/L. Rhinitis and asthma were the clinical symptoms reported most often in patients with a positive skin prick test [27, 28].

### 40.7.1 Contact Urticaria and Platinum

Platinum is a highly reactive transitional metal which easily complexes with donor groups in amino acids to form a complete antigen [29]. The platinum compounds eliciting hypersensitivity are confined to a small group of ionic complexes containing reactive halogen ligands. IgE antibodies to platinum salts have previously been demonstrated in sensitized workers [30]. Chlorinated soluble compounds such as hexachloroplatinic acid ($H_2[PtCl_6]$) and its potassium and ammonium salts, along with potassium and sodium tetrachloroplatinate ($K_2[PtCl_4]$, $Na_2[PtCl_6]$), represent the most dangerous chemical forms [27]. Platinum is used in catalytic converters, laboratory equipment, electrical contacts and electrodes, platinum resistance thermometers, dentistry equipment, and jewelry. Chemotherapeutic compounds containing platinum, such as carboplatin and cisplatin, are applied in the treatment of certain cancer types. Between 12 and 24% of patients receiving oxaliplatin have been reported to develop an immediate hypersensitivity reaction to the drug after multiple intravenous injections [31].

Schena et al. [32] described a 35-year-old nurse, who after 6 months of working in an oncological department developed urticarial lesions on the face, chest, arms, and dorsa of the feet 30 min after preparing cisplatin infusions. The lesions disappeared within 2 h. Open tests with both ammonium tetrachloroplatinate 0.25% and ammonium hexachloroplatinate 0.1% produced urticarial reactions after 40 min. Finally a handling test was also positive.

### 40.7.2 Contact Urticaria and Iridium

Iridium is a silvery-white transitional metal belonging to the PGEs. Iridium is a highly corrosion-resistant metal, even at very high temperatures, and only certain molten salts and halogens are corrosive to solid iridium. Although solid iridium is generally considered non-allergenic [33], finely divided iridium dust is much more reactive. Iridium has found usage as a hardening agent for platinum alloys as well as in dental practice due to its chemical resistance.

Bergman et al. [5] described the only case of contact urticaria caused by iridium in a 26-year-old man working in an electrochemical facility. His daily routines included coating of titanium anodes with various metal salts of the PGEs dissolved in hydrochloric acid. The coating solution was sprayed onto the anodes automatically. The patient initially developed respiratory symptoms. After 5 years of exposure, he also developed urticarial lesions on the wrists that would appear within minutes after exposure and clear completely within hours after exposure seized. Application of iridium salts to normal skin produced an urticarial reaction. Skin prick testing with increasing concentrations of iridium chloride gave a positive reaction to 0.05%, and a scratch test resulted in an anaphylactic reaction which was treated successfully with corticosteroids, antihistamine, and adrenaline. Skin prick tests with platinum salts were negative. The patient subsequently left his job due to the risk of developing a new anaphylactic reaction, and following this his symptoms disappeared.

### 40.7.3 Contact Urticaria and Palladium

Palladium also belongs to the group of PGEs. It is a rare, inexpensive silvery-white metal, which is less resistant to corrosion than platinum. The main uses for palladium are in electrical components and as a catalyst. Small amounts are used as a whitener for white gold in jewelry [21]. Although delayed contact allergy to palladium is common, and almost always seen concomitantly with nickel contact allergy [34], immediate cutaneous hypersensitivity to palladium is rare.

A 50-year-old female laboratory technician [35] working in a catalyst research facility developed an immediate facial erythema when exposed to fine dusts of dried and powdered mixtures containing

palladium nitrate salts. In addition, during accidental spillage of the powder mixtures, urticarial lesions appeared on the contact sites of her forearms. The patient displayed positive skin prick tests with tetraamminepalladium(II) hydrogencarbonate 0.1% and 1% as well as tetraamminepalladium(II) nitrate 10%. Application of the two palladium salts to the forearm of the patient gave a positive open skin application test with urticarial wheals after 20 min. On standard patch testing, the patient was negative to palladium(II) chloride 2%.

## References


1. Thyssen JP, Menné T. Metal allergy—a review on exposures, penetration, genetics, prevalence, and clinical implications. Chem Res Toxicol. 2010;23:309–18.
2. Wakelin SH. Contact Urticaria syndrome. Clin Exp Dermatol. 2001;26:132–6.
3. Giménez-Arnau A, Maurer M, De La Cuadra J, Maibach H. Immediate contact skin reactions, an update of Contact Urticaria, Contact Urticaria Syndrome and Protein Contact Dermatitis—a Never Ending Story. Eur J Dermatology. 2010;20:552–62.
4. Maibach H, Johnson H. Contact Urticaria syndrome. Arch Dermatol. 1975;111:726–30.
5. Bergman A, Svedberg U, Nilsson E. Contact urticaria with anaphylactic reactions caused by occupational exposure to iridium salt. Contact Dermatitis. 1995;32:14–7.
6. Krecisz B, Kiec-Swierczynska M, Krawczyk P, et al. Cobalt-induced anaphylaxis, contact urticaria, and delayed allergy in a ceramics decorator. Contact Dermatitis. 2009;60:173–4.
7. Williams JDL, Lee AYL, Matheson MC, et al. Occupational contact urticaria: Australian data. Br J Dermatol. 2008;159:125–31.
8. Kligman AM. The spectrum of contact urticaria. Wheals, erythema, and pruritus. Dermatol Clin. 1990;8:57–60.
9. Jasmin G. Anaphylactoid edema induced in rats by nickel and cobalt salts. Proc Soc Exp Biol Med. 1974;147:289–92.
10. Estlander T, Kanerva L, Tupasela O, et al. Immediate and delayed allergy to nickel with contact urticaria, rhinitis, asthma and contact dermatitis. Clin Exp Allergy. 1993;23:306–10.
11. Büyüköztürk S, Gelincik A, Ünal D, et al. Oral nickel exposure may induce type I hypersensitivity reaction in nickel-sensitized subjects. Int Immunopharmacol. 2015;26:92–6.
12. Osmundsen PE. Contact urticaria from nickel and plastic additives. Contact Dermatitis. 1980;6:452–4.
13. Malo JL, Cartier A, Doepner M, et al. Occupational asthma caused by nickel sulfate. J Allergy Clin Immunol. 1982;69:55–9.
14. Tosti A, Melino M, Labanca M, Ragazzi R. Immediate hypersensitivity to nickel. Contact Dermatitis. 1986;15:95.
15. Valsecchi R, Cainelli T. Contact urticaria from nickel. Contact Dermatitis. 1987;17:187.
16. Walsh ML, Smith VH, King CM. Type 1 and type IV hypersensitivity to nickel. Australas J Dermatol. 2010;51:285–6.
17. Bregnbak D, Johansen JD, Jellesen MS, et al. Chromium allergy and dermatitis: prevalence and main findings. Contact Dermatitis. 2015;73:261–80.
18. Zachariae CO, Agner T, Menné T. Chromium allergy in consecutive patients in a country where ferrous sulfate has been added to cement since 1981. Contact Dermatitis. 1996;35:83–5.
19. Aslan A. Determination of heavy metal toxicity of finished leather solid waste. Bull Environ Contam Toxicol. 2009;82:633–8.
20. Pizzino J. Letter to the editor: possible chromate-associated urticaria. J Occup Med. 1993;35:96–7.
21. Lidén C, Bruze M, Thyssen JP, Menné T. Chapter 35—Metals. In: Johansen JD, Lepoittevin JP, Frosch PJ, editors. Contact dermat. 5th ed. Berlin, Heidelberg: Springer; 2011. p. 643–79.
22. Smith JD, Odom RB, Maibach HI. Contact Urticaria from cobalt chloride. Arch Dermatol. 1975;111:1610–1.
23. Bagnato GF, De Pasquale R, Giacobbe O, et al. Urticaria in a tattooed patient. Allergol Immunopathol (Madr). 1999;27:32–3.
24. Siemund I, Zimerson E, Hindsén M, Bruze M. Establishing aluminium contact allergy. Contact Dermatitis. 2012;67:162–70.
25. Bergfors E, Hermansson G, Nyström Kronander U, et al. How common are long-lasting, intensely itching vaccination granulomas and contact allergy to aluminium induced by currently used pediatric vaccines? A prospective cohort study. Eur J Pediatr. 2014;173:1297–307.
26. Helgesen AL, Austad J. Contact urticaria from aluminium and nickel in the same patient. Contact Dermatitis. 1997;37:303–4.
27. Santucci B, Valenzano C, de Rocco M, Cristaudo A. Platinum in the environment: frequency of reactions to platinum-group elements in patients with dermatitis and urticaria. Contact Dermatitis. 2000;43:333–8.
28. Cristaudo A, Sera F, Severino V, et al. Occupational hypersensitivity to metal salts, including platinum, in the secondary industry. Allergy Eur J Allergy Clin Immunol. 2005;60:159–64.
29. Guy RH, Hostynek JJ, Hinz RS. Chapter 29—Platinum. In: Metals and the skin: topical effects and systemic absorption. Ann Arbor, MI: CRC Press, ProQuest ebrary; 2016.

30. Cromwell O, Pepys J, Parish WE, Hughes EG. Specific IgE antibodies to platinum salts in sensitized workers. Clin Allergy. 1979;9:109–17.
31. Park H, Lee J, Kim S, et al. A new practical desensitization protocol for Oxaliplatin-induced immediate hypersensitivity reactions: a necessary and useful approach. J Investig Allergol Clin Immunol. 2016;26:168–76.
32. Schena D, Barba A, Costa G. Occupational contact urticaria due to cisplatin. Contact Dermatitis. 1996;34:220–1.
33. Stingeni L, Brunelli L, Lisi P. Contact sensitivity to rhodium and iridium in consecutively patch tested subjects. Contact Dermatitis. 2004;51:316–7.
34. 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;64:185–95.
35. Pesonen M, Airaksinen L, Voutilainen R, et al. Occupational contact urticaria and rhinitis caused by immediate allergy to palladium salts. Contact Dermatitis. 2014;71:176–7.