# Contact Sensitivity to Dental Prosthetic Materials - Alloys

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Summary

*Type IV reactions, reactions of delayed hypersensitivity, are manifestations of cellular immunity. Such reactions are caused by sensitised T-lymphocytes. In dental medicine contact sensitivity is of particular interest, as restorations are in long-term direct contact with oral tissues and saliva and during function they wear and bend, leading to corrosive processes which result in the release of ions, their accumulation in the tissues and possible sensitivity, i.e. allergic reaction. Dentists need to chose alloys with less tendency to the release of ions, in other words good biotolerance. It is recommended that the use of alloy with a high share of nickel should be avoided. Patch test is indicated for all patients with a history of hypersensitivity to metal or other materials used in the construction of a prosthetic restoration.*

Key words: *contact hypersensitivity, dental prosthetic materials - alloys, patch test.*

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## Introduction

Reactions of hypersensitivity to prosthetic materials used in dentistry have still not been entirely explained. The dramatic increase in the incidence of allergic diseases in the general population (1), and the large number of new prosthetic fabrication and auxiliary materials on the market, constitute an intriguing combination. The aetiology of a lesion in the oral cavity, developing after insertion of a restoration is frequently unclear, the opinion of clinicians varied and diagnosis challenging and costly (2).

This article will attempt to answer the question of whether prosthetic patients, because of direct, long-term contact with a restoration are a risk group or exempt from the problem of allergy.

Thanks to Spector (1951) allergological testing to dental prosthetic alloys gained importance, became acknowledged and was gradually introduced into practice (3). The introduction of fluorescent X-ray spectroscope, electronic microscope and Energy Dispersion X-ray Microanalysis System (EDX), the detection and quantification of metal ions released from fixed prosthetic restorations in saliva and gingival fluid (4) and analysis of specimens (5-7) became simpler and greatly contributed to illuminating the problem of allergies in industry. Ten of the most frequently released metal ions are ions of silver, copper, zinc, nickel, gold, palladium, kositer, indium and chromium (4).

The basic criterion in the choice of the material for a restoration is its biological tolerance. However, the occurrence of undesired reactions, chemical, toxic, allergic or even cancerogenic, raises scepticism with regard to the lack of clinical research or even incomplete description of the material composition (8-12).

With their insertion into the oral cavity restorations are simultaneously exposed to different processes: bending, wear and corrosion (13), during which the disintegration of the passive layer on the surface of the restoration occurs, uniform corrosion and dissolution of the material and release of ions (14). Wear of the restoration increases the surface from which increased amounts of ions are released. Corrosion and wear, with the release of ions, close the vicious circle. Fractures and grooves are the most frequent sites affected by corrosion (15). The existence of different types of metal in the mouth (in direct contact with saliva as an electrolyte and without an isolator) can easily induce galvanic corrosion, resultant passivity and the release (16) and accumulation of metal remains in the tissue (17-20).

In 1963 Coombs and Gell proposed classification of allergic reactions according to immune mechanisms which cause tissue damage. According to their classification (supplemented in 1975) allergic reactions are classified as humoral: type 1, type 2 and type 3, and cellular: type 4, which is the most important type for the dentist. Type 4 reaction is caused by specifically sensitised T-lymphocytes, and is determined by patch test. The reaction develops slowly at the site of contact with the antigen, similarly to inflammation. It takes 48-72 hours for the reaction to become positive, and in the cellular infiltrate lymphocytes and Langerhan cells are characteristic. After contact with the antigen recruited cells (monocytes, basophils and neutrophils) and resident cells (mononuclear phagocytes, mastocytes) become active. With the release of metal ions from the restoration so-called sensitising agents form, which are not antigens but which acquire such characteristics by binding to tissue (directly or after intermediary chemical reactions) creating a conjugate hapten-protein. These complexes cause sensitisation and delayed hypersensitivity whenever the skin or mucosa comes into contact with the same or a chemically similar substance (21, 22).

Several cases have been described of stomatitis, stomatopyrosis, lichen, lichenoid reactions and other diseases of the oral cavity, developing after insertion of a restoration (23-25). Marcusson (26) associated the insertion of a prosthetic restoration and hypersensitivity to nickel with the occurrence of chronic tiredness syndrome, impaired concentration, disturbed sleep, headaches, pain in the joints and muscles and sensitive teeth. He also reported burning mouth and tongue, dry mouth, a feeling of electricity in the mouth and pain and TMZ fatigue (27). Merritt (19) described the occurrence of metal taste in the mouth after prosthetic treatment with a restoration of cobalt-chromium alloy.

The occurrence of contact dermatitis has also become more frequent in therapists and dental technicians, particularly after long-term exposure to prosthetic materials (28-31), and occurs in other fields of dentistry (32-33).

## Diagnosis of delayed hypersensitivity

Careful case history is the first link in the chain for diagnosis of allergy, during which it is necessary to determine earlier allergic diseases and the existence of atopic diathesis. Information on current therapy is also important, and the environment in which the patient lives, profession and workplace, types of preparations used for personal hygiene, etc. (34). Van Arsdel (35) proposes allergological analysis for each patient with a positive history, prior to prosthetic therapy.

The allergological test in the diagnosis of delayed hypersensitivity, which is performed on patients (in vivo), is the patch test, and if necessary *in vitro* tests are also performed (36). Patch test is a biological test by which the presence or absence of delayed allergic reaction to a specific antigen is determined (37). Testing is performed in accordance with the recommendations of the International Contact Dermatitis Research Group (ICDRG) (34). Allergens in a non-toxic concentration are used, usually 2% vaseline, paraffin, water (38), petrolatum (39) or some other solvent (methanol, ethanol, acetone) (40), placed in a disk of cellulose, covered with impermeable aluminium paper and covered with polyethylene. Allergens are placed on clean, intact skin, usually of the upper part of the back or upper outer part of the upper arm, where they remain covered for 48 hours, until the first results are read and after 72 and 96 hours. Reactions may be negative (individuals not sensitised to a particular antigen) or positive, depending on the intensity of the reaction, and classified as follows:

+ Insignificant erythema and oedema with redness, possible papules without vesicles.

++ Insignificant erythema, oedema, sporadic papules and one or two vesicles.

+++ Numerous papules and vesicles, sporadic bullae, eroded surface and extreme moistness (36, 37, 41).

There is a possibility of false positive and false negative results. Namely, a false positive result is caused by an extremely high concentration of hapten, cross-reaction with undefined substances, inflammation near the tested site, irritation after occlusion, etc. The reasons for false negative results are errors in the technique of performing the test and anergy (temporary or permanent). Temporary anergy may be caused by acute infections, vaccination, radiation, acute alcoholism, and immunosuppressive drugs. Permanent anergy may be caused by diseases of the lymph system (lymphoma, chronic anaemia), malignant tumours and other serious chronic diseases, age, spontaneous loss of delayed hypersensitivity in otherwise healthy individuals, and numerous other unknown genetically conditioned reasons (35, 42).

The test can be performed epimucously, and Axell (43) described intraoral testing. In diagnosis of delayed hypersensitivity in clinical immunology, *in vitro*, migration inhibition test and lymphocyte transformation tests are used (36, 44). Some studies have been engaged in the identification of metal-specific lymphocytes, which are used as biomarkers during diagnosis of hypersensitivity (45).

**Allergenic potential of metals**

Schaffran (46) reported some interesting correlations. Namely, patients positive to gold were also positive to nickel, and those positive to palladium were also positive to nickel. The risk of the use of palladium in dental prosthetic alloys is extremely low due to the low values of released palladium ions (46). Kansu and Aydin (47) put platinum and its salt in seventh place with regard to allergenic potential.

Allergy to chromium can only occur through transformation into six-valency salt-chromium. Sensitisation is facilitated by exposure to detergents, bleaches and cosmetic preparations (48). In his investigations Merritt (49) and Sunderman (50) showed that all cobalt ions administered orally were excreted in the urine within 48 hours.

Allergies to nickel are more frequent in industrially developed countries and more frequent in women (10%) than men (1-2%), probably because of their sensitivity via jewellery (48,51). Nickel causes more contact allergic reactions than all other metals together, and even in those alloys which contain a very small concentration of nickel (1.5%) (47). Allergenic effects of nickel and beryllium in dental patients and the toxic effects in dental technicians represent a potential problem in dentistry (52, 53). Corrosion of alloy containing nickel results in the release of ions and their accumulation both in adjacent tissue (54-58) and in distant organs (59, 60). However, Goh (53) states that systemic response to elementary nickel and nickel compounds over a longer period has still not been sufficiently investigated. It is known that some alloys, based on nickel, particularly those which contain beryllium, are prone to intense corrosion, particularly at lower pH values (52, 57). In sensitised individuals the concentration in alloys is not decisive for provoking allergic reactions (62, 62). The concentration of nickel of 2.5 μg/mL proved to be toxic for gingival cells in tissue culture (63). Ions of nickel, cobalt and chromium bind to proteins (most frequently albumin) and are thus transported through the body. Binding has a tendency to reversibility and metal can be transported to a specific site (e.g. the kidney) freed of proteins and eliminated via the urine. Nickel administered orally to experimental animals was excreted in the urine within 24 hours (64, 65). Although research on the role of metal ions is limited, it is known that nickel is chemo-attractive and therefore increases acute inflammatory reaction, which is usually of short duration, although cases have been reported of longer duration (66). In some compounds, particularly subsulphide or nickel-carbonyl, nickel has proved carcinogenic in the case of constant exposure at the workplace (67-69). The presence of allergy to nickel has proved decisive for determination of sensitivity to palladium, because the majority of people (93-100%) who are hypersensitive to palladium ions are also hypersensitive to nickel (20). According to Geurtsen, this percentage is much lower and amounts to 34-65.5% (11).

The aforementioned clinical cases could lead to the wrong conclusion that alloy with nickel will frequently induce an allergic reaction, which in clinical practice is not the case. Such cases are few and the majority of recent studies on the clinical use of alloy with a specific share of nickel, for orthopedic and dental purposes, have demonstrated its wide application without the occurrence of allergy (70). Namely, if the high percentage of the population who are allergic to nickel (15% according to Gohu) (53), rejected restorations containing this metal, there would be cause for great concern, as it is present in the composition of many dental prosthetic alloys.

Although the frequency of hypersensitivity and allergic response cannot be disregarded, it should be kept in mind that there are many more people with hypersensitivity to metal than those who actually react to a prosthetic restoration (71).

Allergies to gold are contradictory. Anhlide (72) states that allergies to prosthetic restorations fabricated from gold alloys do not exist, and this assertion is corroborated by Alanko (40), while Ahlgren (73) and Björkner (74) point out the occurrence of contact allergies and positive skin test to gold salt.

Indium-sulphate, indium-chloride and iridium chloride are inert compounds (75). Zinc, rubidium, reni, silica, manganese, tungsten and other elements are included in dental prosthetic alloys in a lower percentage, and no allergy to them has been found in available literature. Cadmium, once in use, has been rejected because of its carcinogenicity (76).

More recently titan has become a particularly interesting material in prosthetics, because of its low cost and biocompatibility. The resistance of titan to the environment primarily depends on the thin, resilient membrane of the surface oxide. This passive oxide membrane is stable in a wide range of pH potentials and temperatures. Consequently, titan is generally resistant to mildly reductive, neutral and highly oxidative environments. This oxide film only disintegrates under highly reductive conditions, when there is a possibility of corrosion, although such conditions are not usually found in the mouth. Paradoxically to the above, overuse of the most frequent preventive means in dental medicine and surface application of fluorides, can have a harmful effect on the self-formed protective film (77).

## Conclusion

The frequent occurrence of allergic reactions to different substances includes the possibility of the development of hypersensitivity to dental prosthetic restorations and auxiliary materials. Prosthetic alloys, their composition and technological treatment, i.e. quality of the cast, contribute to the achievement of better structures and characteristics in clinical application. A restoration in the mouth is subject to corrosive processes, the release of ions and formation of corrosive complexes which can lead to sensitisation of the organism. Nickel induces more contact allergic reactions than all other metals together. In their elementary state chromium and platinum are not allergenic, although their salts may show such an effect.

Palladium and platinum show exceptionally low values of ion release from alloys and thus the risk of the use of dental prosthetic alloys containing these elements is low. In the case of gold contradictory data can be found in relevant databases, although clinicians agree that highly precious gold alloys are very reliable in the oral cavity.

In the case of doubt, based on patient information, clinical finding or clinical tests on allergy to any dental prosthetic material, prior to construction of the restoration, tests must be carried out on the targeted allergens and relevant blood tests performed, after which the material can be selected for construction of the restoration. An exceptionally thorough case history, which in everyday dental practice is often absent, will once again be useful and unavoidable. It is a mistake to solve problems when symptoms occur, both from the ethical and the material viewpoint. Thus, the dentist should be encouraged to respect all the above steps, particularly in the case of patients with atopic history. On the other hand it is unnecessary and costly to carry out allergological testing for all prosthetic patients, because of the extremely small number of those in whom allergic reaction develops after insertion of a restoration.