Prosthodontic biomaterials and adverse reactions: a critical review of the clinical and research literature

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Lygre H. Prosthodontic biomaterials and adverse reactions: a critical review of the clinical and research literature. Acta Odontol Scand 2002;60:1–9. Oslo. ISSN 0001-6357.

Prosthodontic biomaterials include impression materials, luting cements, and restorative materials. They consist of metals and alloys, ceramics, and polymer materials and are retained in patients for <60 min or for decades. Oral release of compounds from biomaterials occurs, and adverse reactions may follow dental treatment. Especially in allergically vulnerable patients contact allergy may occur. There are reports from many different countries on contact allergy from gold/palladium alloys, components from polymer-based materials, chromium/cobalt alloys, and nickel. Notifications on adverse reactions in Norway, Sweden, and England are handled by a registry in which patient reactions and occupational exposure are recorded. Data from The Adverse Reaction Unit in Bergen and Umeå have been a most valuable basis in extending knowledge in a field of current interest in dentistry. A review of the clinical and research literature relating to prosthodontic biomaterials and adverse reactions shows that reliable methods seem necessary to expose the frequency of adverse reactions in general dentistry, including prosthodontic treatment. □ *Dental materials, adverse effects; prosthodontics*

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Contact between dental materials and saliva/oral tissues, temporarily or permanently, results from prosthodontic treatment. Previously, gold-alloys and heat-cured acrylates dominated this type of treatment, and few adverse reactions were observed. Today, prosthodontic treatment aspires to fulfill, in addition to the restoration of function, high esthetic demands. New materials are frequently introduced to dentistry. In Germany more than 800 dental alloys are available. Ceramics, metal ceramic restorations, polymer-based materials, and combinations of materials offer multiple treatment-possibilities in oral prosthodontic treatment.

The denotation biomaterial is used for medically applied materials in contact with human tissue either temporarily or permanently (1). Biomaterials are used in orthopedics, cardiovascular surgery, and plastic surgery. In dentistry they occur in prosthodontics, endodontics, implantology, and as restorative materials. Their use may be temporary—that is, <60 min; short (<30 days); or long-standing (>30 days). Biomaterials that result in few biological reactions are classified as biocompatible (1). Most reactions from dental materials are allergies with symptoms from the skin and oral tissues.

This review has been based on a report from the Scandinavian Society for Prosthetic Dentistry (2). The aim of the present review is to give an updated report on factors that may influence the frequency of adverse reactions in prosthetic dentistry. A description of dental prosthetic materials is given. Material degradation related to adverse reactions is explained, and potential types of adverse reactions are described.

Biomaterials in prosthodontic dentistry

Biomaterials in prosthodontic dentistry encompass impression materials, luting cements, and restorative materials. They are mainly used to replace oral hard and soft tissue.

Impression materials

Two main groups of impression materials exist: non-elastic and elastic. Non-elastic materials include gypsum products, wax materials, and thermoplastic materials. Elastic materials are classified into two groups: the elastomers and the hydrocolloids, the latter of which exists as an irreversible (alginate) and a reversible type (agar). Polymer-based elastomers include types of A (addition-polymerized) and C (condensation-polymerized) silicones, polyether, and polysulfides. The A silicones are built up of two types of chains, of which one contains an end-group of silane and the other an end-group of vinyl. When these two types of chains are mixed, an exchange of atoms can occur between the two chains. This is why they are called polyvinylsiloxanes.

Luting cements

To fasten crowns and fixed partial dentures (FPD), water-based or polymer-based types of cements may be used. Water-based cements include zinc phosphate, zinc polycarboxylate, and glass-ionomer. The latter may be subdivided into traditional types, metal-reinforced or

polymer-based, of which the latter includes exclusively polymer materials, composites, and compomers. Luting cements for temporary use may or may not be based on eugenol.

Prosthodontic restorative materials

Oral prosthodontic treatment encompasses veneers, complete or partial single crowns, FPD, removable complete or partial dentures (RPDs), and constructions based on implants, either removable or fixed types. The range of materials used includes metals, ceramics, and polymers.

Metals and alloys. Dental alloys may contain more than 30 different metals. Metals may be classified as essential or non-essential. The essential metals (that is, metals that are necessary for the body) may induce toxic reactions in humans at high concentration. Prosthodontic treatment uses materials of both precious and non-precious types. By spectroscopic techniques it is possible to determine the most frequently used metals in dentistry: Ag, Cu, Zn, Au, Pd, Sn, Hg, In, Ni, and Cr (3).

Many types of alloys have been used in prosthodontic treatment: mixtures of precious metals (Au, Pt, Pd), combinations of non-precious and precious metals, and mixtures of non-precious types of metals. The physical properties of alloys differ from those of single ingredients. Precious alloys for crowns and FPDs may contain Au, Pt, Pd, Cu, Ag, and Zn in various amounts. They may also include Ir, In, Ru, and Ga. In high-precious alloys (Au + Pt + Pd > 75%) Au dominates, and in low-precious alloys (Au + Pt + Pd 25%–50%) Ag may dominate (that is, Ag/Pd alloys). Silver-based alloys are mixtures of Ag/Sn/Zn and Ag/In. Palladium-based alloys consist of Pd/Ag, Pd/Cu, Pd/Co, Pd/Ga/Ag, or Pd/Ga/Ag/Au (4). Copper-based alloys—that is, alloys made of Cu/Al—have been widely used in South America (5).

The alloys most commonly used to make RPDs are Ni/Cr and Cr/Co, with small amounts of C, Mo, Be, W, and Al. Alloys made of Ni/Cr and Co/Cr may also be used for metal ceramic restorations (6).

Gold, Pd, and Pt are often used in alloys combined with ceramics and polymers/composites, in common metal ceramic restorations, molded metal restorations, and in crowns made of gold foil. Cobalt is used in a few Ag/Pd and Au alloys, in some Ni/Cr alloys, and in Co/Cr alloys. Alloys of Co/Cr and Mo may contain Ni, which is a common allergen. Pure metals are seldom used; however, Au made by an electrolytic process may be used in galvano crowns. Titanium is used both in chemically or commercially pure forms for implants and the components of implants and also as a material for crowns, FPDs, and cores. Titanium is also used in different alloys including Al, V (Ti—Al–V), Cu (Cu–Ti), Co (Co–Ti), and Ni (Ni–Ti) (7).

In recent years the use of Ti for dental or medical implants has increased because of its favorable biocompatibility, good resistance against corrosion, and advantageous physical properties (8). The melting temperature of Ti (1600°C), however, represents a challenge. By adding 25% Co, it is possible to decrease the melting temperature to 600°C, resulting in a lower material resistance against corrosion. This disadvantage can be reduced by adding 5% Ni, but a lower biocompatibility then results. It has been suggested that a classical alloy consisting of Ti–6Al–4V may be responsible for the possible toxic effects caused by Al and V. Two alloys are available, containing either Ti, Nb, Ta, and Pd or Ti, Sn, Nb, Ta, and Pd. From a dermatological point of view, Pd may in the future result in a higher incidence of contact allergy among dental patients (9).

Ceramics. For dental use ceramics are composed of metal oxides and half-metals. Silicium dioxide, Al_2O_3, K_2O, MgO, CaO, and B_2O_3 are the most frequently used oxides (6).

In production of crowns and veneers feldspathic ceramic (a mixture of feldspar, quartz, and kaolin) has been the most usual ceramic (10). The latest feldspathic materials have been reinforced with Al_2O_3 (that is, Hi-Ceram, Vita) and fibers of Zr (Mirage). Glass-ceramic materials are also used, as leucite-reinforced feldpathic ceramics (IPS Empress) or tetrasilic micaglass (Dicor). In recent years mixtures of Al_2O_3 and continuous interpenetrating-phase composite ceramics have been introduced (In-Ceram Alumina). Variants of these materials (In-Ceram Spinell, Procera, AllCeram) and ZrO_2 with YO (Denzir) have also been introduced. Ceramic-fused-to-metal is usually produced with SiO_2 and contains oxides from Na, K, Ca, Al, B, and Zn. The colors of ceramics are made by the addition of oxides of Fe, Ni, Cu, Ti, Mn, and Co, in addition to Sn, Zr, and Ti.

Polymer materials. To manufacture removable complete or partial dentures, or veneers for crowns and FPDs, polymer-based materials are used. Complete crowns may also be produced with monomers in a polymerization process in which the material is loaded by ceramic particles and fibers (11). Various materials have been used for the production of prostheses: (poly)acrylic acid esters, (poly)substituted acrylic acid esters, (poly)vinyl esters, polystyrene, rubber-modified (poly)metacrylic esters, polycarbonates, polysulfones, and mixtures of the above-mentioned polymers (12). Polyacetal is a polymer made from formaldehyde and used to make tooth-colored brackets in RPDs. Polyurethane has also been applied for the production of dentures. (Poly)methyl methacrylate (PMMA) is the most common polymer used to make removable complete and RPDs. These dentures are made of pre-polymerized particles of PMMA, a monomer system with one or more oligo- or polyfunctional methacrylates and an initiator system such as benzoyl peroxide. PMMA contain phthalates, stabilizers, and antioxidants, and dentures made of acrylates are polymerized by free-radicals either by heat or by chemicals (13). Many efforts have been made to improve the tensile strength of PMMA dentures by, for example, the addition of polyethylene with a very high molecular weight (14). Until now it has

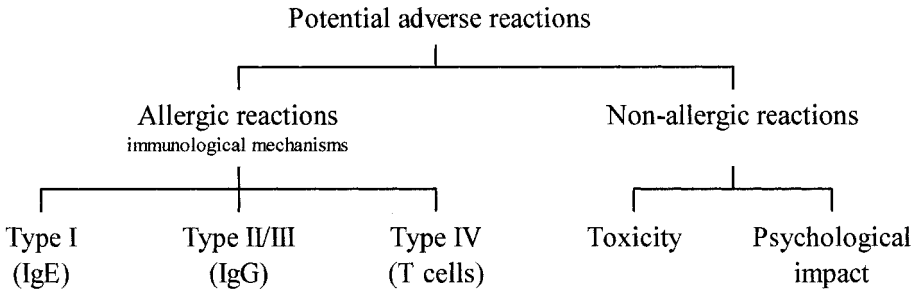

Fig. 1. Potential adverse reactions to biomaterials.

not been possible to evolve better materials replacing the extensive clinical use of PMMA for denture production.

Dental prosthetic materials and adverse reactions

Biodegradation/corrosion/inactivation

Biological systems may have harmful or destructive effects on materials, classified as biodegradation (15). In the oral environment this includes the process of destruction and dissolution in saliva but also chemical/physical destruction, wear and erosion caused by food, chewing, and bacterial activity. The most important contribution to the process of prosthetic metal-alloy biodegradation is corrosion. In a physiological milieu chlorine and oxygen are responsible for the corrosive process. Release of metallic ions into the oral cavity occurs from the metallo-lattice in non-precious alloys, and thermostable substances, such as chlorides, sulfides, and oxides, are formed during this process.

It is possible to increase resistance to corrosion by using an alloy that makes strong chemical bonds with oxygen. A protective film is created on the surface of the materials. In this manner the transition of metallic ions to the water-phase is reduced. The content of Cr in stainless steel and dental Co/Cr alloys is responsible for their resistance to corrosion, and a stable film of chromium–oxide results. Titanium, however, is highly reactive and produces a strong film of oxides without involving other metals (16).

Besides being corroded, alloys may also be tarnished, abraded, and eroded (4). In this context it is important to remember that inert metals do not exist. All types of metals may be attacked by their environment in one way or another (17).

Release of components from prosthetic biomaterials

The release of substances from dental materials is considered to be gradual and to occur in small amounts (18). Alloys used in prosthetic dentistry have been shown to release ions. Nickel, Cr, and Be (19) and also Pd may be eluted into the oral cavity (20). Cobalt is released as ions by a process of alloy corrosion, and Cd has been found to be eluted from dentures (21).

In most reports on compounds released from dentures made of acrylate, only the monomer methyl methacrylate has been detected (22–27). It was initially detected in the mid-1950s (28). Nevertheless, the finding of this monomer in saliva from patients wearing removable dentures occurred 30 years later (29). Subsequently, Koda et al. (30) reported on the elution of methacrylic acid and benzoic acid to artificial saliva, and Ruyter (31) showed that formaldehyde may be eluted from denture acrylate. Later, Lygre et al. (32) detected the aromatic compounds dibutyl phthalate, phenyl benzoate, and phenyl salicylate in saliva from patients wearing a removable denture consisting of acrylate.

The aromatic compounds biphenyl, dicyclohexyl phthalate, and 2-methoxy-4-hydroxy-benzophenon e have been shown to be released from (poly)methyl methacrylate denture materials in vitro (33). In addition, it was shown that the total amount of these organic compounds released was increased by lowering the production temperature of the dentures (33). Soft-tissue lining materials based on (poly)ethyl methacrylate for prosthetic use have also been shown to release high amounts of phthalate esters both in vitro and in vivo (34, 35).

Very few investigations have confirmed the release of components from ceramic biomaterials. Theoretically, two mechanisms may dominate in water-based corrosion from alkali-silicate glass: 1) release of alkalide ions, and 2) destruction of the glass network. It is supposed that the first-mentioned mechanism may dominate at a pH value below 9. However, this is not based on actual research on dental ceramics but exclusively on knowledge about the structure and chemical properties of ceramic materials (4).

Fate of released substances in the human body from prosthetic materials

Compounds released from dental materials are supposed to be absorbed in the gastrointestinal tract, in the

oral mucosa, from the skin, or in the respiratory system. The mechanism for this absorption depends on the nature of the chemical properties of the released elements—whether they exist as ions, as hydrophilic and lipophilic compounds, as volatile substances, or as particles.

The molecular transport through cell membranes may be by an active transport mechanism. Other membrane transport processes are also available. Active transport requires energy and must in some way be linked to energy metabolism (36). Besides the controversy about the fate of released mercury in patients with amalgam, information about the fate of released compounds from dental materials in humans is scanty.

Exposure/toxicity

Adverse reactions to dental materials in patients depend on the release of compounds. The contact between biomaterials and saliva may promote a release of compounds to the oral cavity by creating the processes of electrolysis and hydrolysis.

Potentially, different mechanisms of toxicity and allergy may occur in connection with compounds released from dental materials (Fig. 1). The mechanisms may be combined, but primary toxic mechanisms also occur. Xenobiotic transport to the immune system may take place. Subsequently, it is important to distinguish between the concepts of exposure and toxicity. The denotation exposure means exclusively that an individual is in contact with a xenobiotic. The concept of toxicity includes adverse effects from xenobiotics (37).

Hypersensitivity/allergy

An increased reaction against stimuli characterizes the process of hypersensitivity. Initially the symptoms start in the skin, the mucosa of the eyes, the respiratory tract, or the gastrointestinal tract. Hypersensitivity may be classified into four different types (I–IV) (38). The term allergy is used to define a strong immunological reaction to substances, which usually represent no harm to the human being. Previous contact with immunologically active cells (lymphocytes) is a prerequisite for a substance to give an allergy (39). Fundamentally, all of the four groups may result from contact with dental biomaterials.

Type I. Anaphylactic reactions, antibody-mediated. Immunoglobulin antibodies (IgE) bind to receptors on mast cells. Pharmacologically active compounds may be released. The clinical effect may be an obstruction of the respiratory system and a cardiovascular collapse.

Type II. Cytolytic or cytotoxic reactions. These occur when immunoglobulins (IgM or IgG) bind to antigens on the surface of cells and activate complement. Complement is a protein system. This activation may result in cytolysis, phagocytosis, chemotactic reactions, and so forth.

Type III. Immune complex reactions. These take place when complexes made of IgM and IgG antibodies accumulate in blood vessels or tissue and activate the complement system.

Type IV. Delayed-type hypersensitivity reaction. This is an immunity mediated by T cells, usually CD4+. Cytotoxin is released, and macrophages are activated, which in turn cause local damage. Acute local damage results from activation of macrophages by hydrolytic enzymes and toxic oxygen metabolites. Chronic contact-allergy reactions often result in fibrosis by secretion of cytokines and growth factors from macrophages (40).

The most common adverse reactions from dental materials are type I—that is, IgE-mediated anaphylactic reactions—and, even more frequent, type IV—that is, T-cell-mediated reactions, delayed-type hypersensitivity. Adverse reactions may also occur without involving immunity—that is, psychologic and toxic reactions. However, the most usual reactions are linked to allergic mechanisms.

Contact allergy

Contact allergy is based on compounds with low molecular weight (haptens) made immunogenic by conjugation with proteins. By this mechanism complete antigens are made, and these may induce sensibilization of immunocompetent cells. Cells of Langerhans in epidermis function as antigen-presentating cells. Only small molecules may penetrate the intact stratum corneum to reach the epidermal cells of Langerhans and give allergic contact dermatitis, which is quite usual. Allergic contact dermatitis is a clinical manifestation of contact allergy—that is, a delayed dermal hypersensitivity reaction.

Contact allergy has four characteristics: it is acquired; it is specific; it can be transformed by cells; and it can be memorized. These characteristics have an immunological basis. Nearly all allergens that induce allergic contact dermatitis have low molecular weight and function through haptens. The skin and local lymph nodes have an important role in induction and in provoking allergic contact dermatitis. The phase of induction of allergic contact dermatitis may be divided into three steps: 1) macrophages and/or Langerhans cells come into contact with antigens; 2) antigen information is transformed to a special class of T lymphocytes by the lymph nodes; and 3) these T cells cooperate with other subgroups of effector-type T lymphocytes.

A prerequisite for contact allergy to occur is that a stable bond is made between the metal-salt and an electron-rich part of a protein. Nickel, Cr, and Co have the properties to make stable bonds with electron-rich groups (41).

Chemical bonds/contact allergy

Allergic contact dermatitis reactions are without doubt one of the pathological conditions in which chemistry plays an important role. Chemical reactions and interactions are involved throughout the entire biological process. The ability to cross the dermal barrier is related to the physiochemical characteristics of the allergen. However,

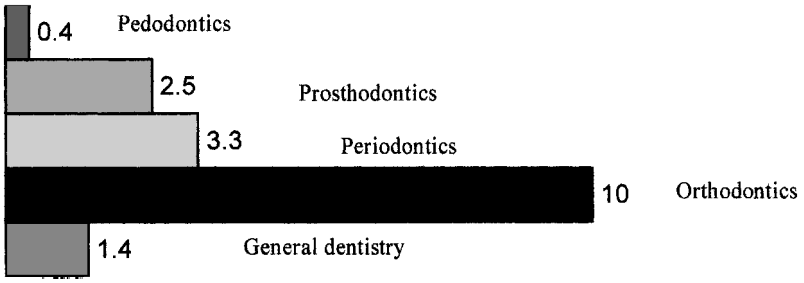

Fig. 2. Occurrence of adverse reactions per 1000 patients after various types of dental treatment (Jacobsen and Hensten-Pettersen 1989, 1991).

the formation of hapten–protein complexes is determined by the chemical bonds in the molecule. When the antigen recognizes the receptors on the T lymphocytes, this is decided by the supramolecular chemistry of the compound.

Contact allergy and the patch test

The patch test is used to distinguish between an allergic reaction and an irritation in dermatology. This is a diagnostic tool for contact allergy. The patch test is used when a contact allergy is suspected as a response to dental biomaterials, because testing on oral mucosa is very complicated and cannot be used as a routine test-method. The dental screening series (Chemotechnique Diagnostics, Malmö, Sweden) for patch testing contains 34 different compounds, in accordance with the European standard. The test compounds are placed on the skin (back) and removed after 2 days. Test sites are evaluated after 3–4 days and 7 days after removal of the test substances. Patch tests should be performed by a dermatologist.

Oral contact allergy may manifest itself as redness, swelling, mucosal erosion, or lichenoid reactions. In those cases in which this reaction is near dental fillings or prosthetic restorations, the indication for testing is obvious. However, lichenoid reactions may be allergenic or non-allergenic. Oral itching may also be used as a suspected indication for patch testing.

To find a possible connection between an adverse reaction and dental materials, the patients should present objective symptoms in addition to a positive patch test.

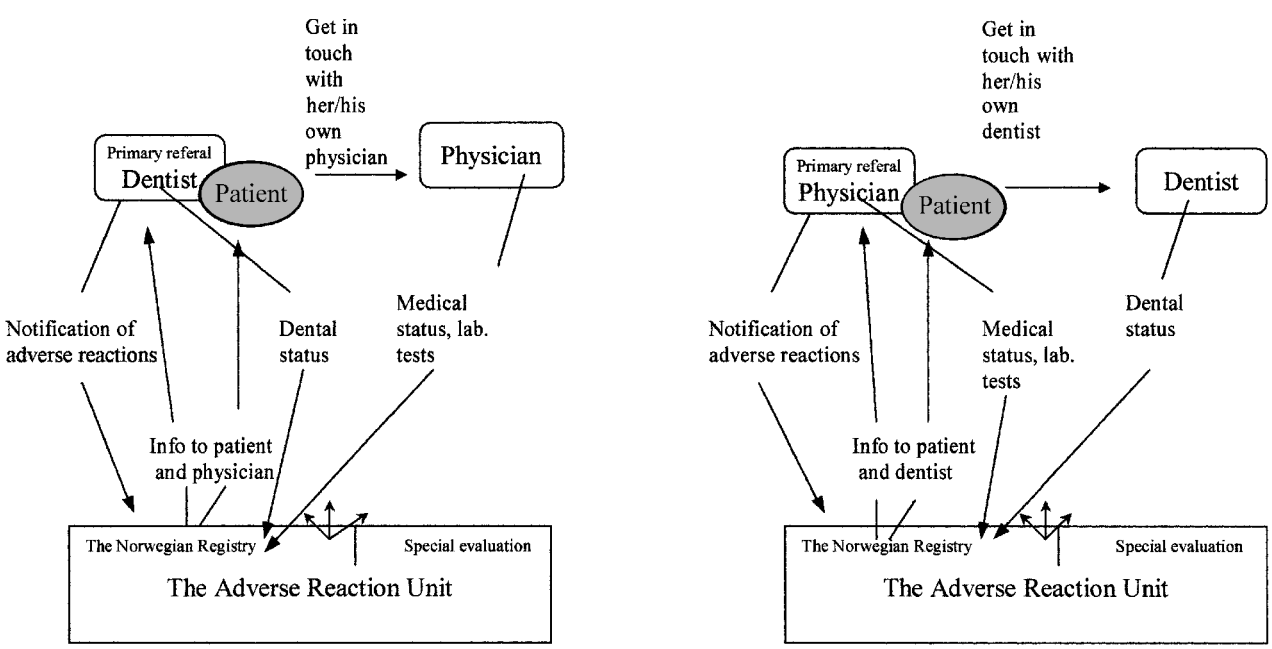

Fig. 3. Current procedures for referrals to The Adverse Reaction Unit in Bergen. Initial referral is from a dentist or physician. (Presented with kind permission from The Adverse Reaction Unit in Bergen.)

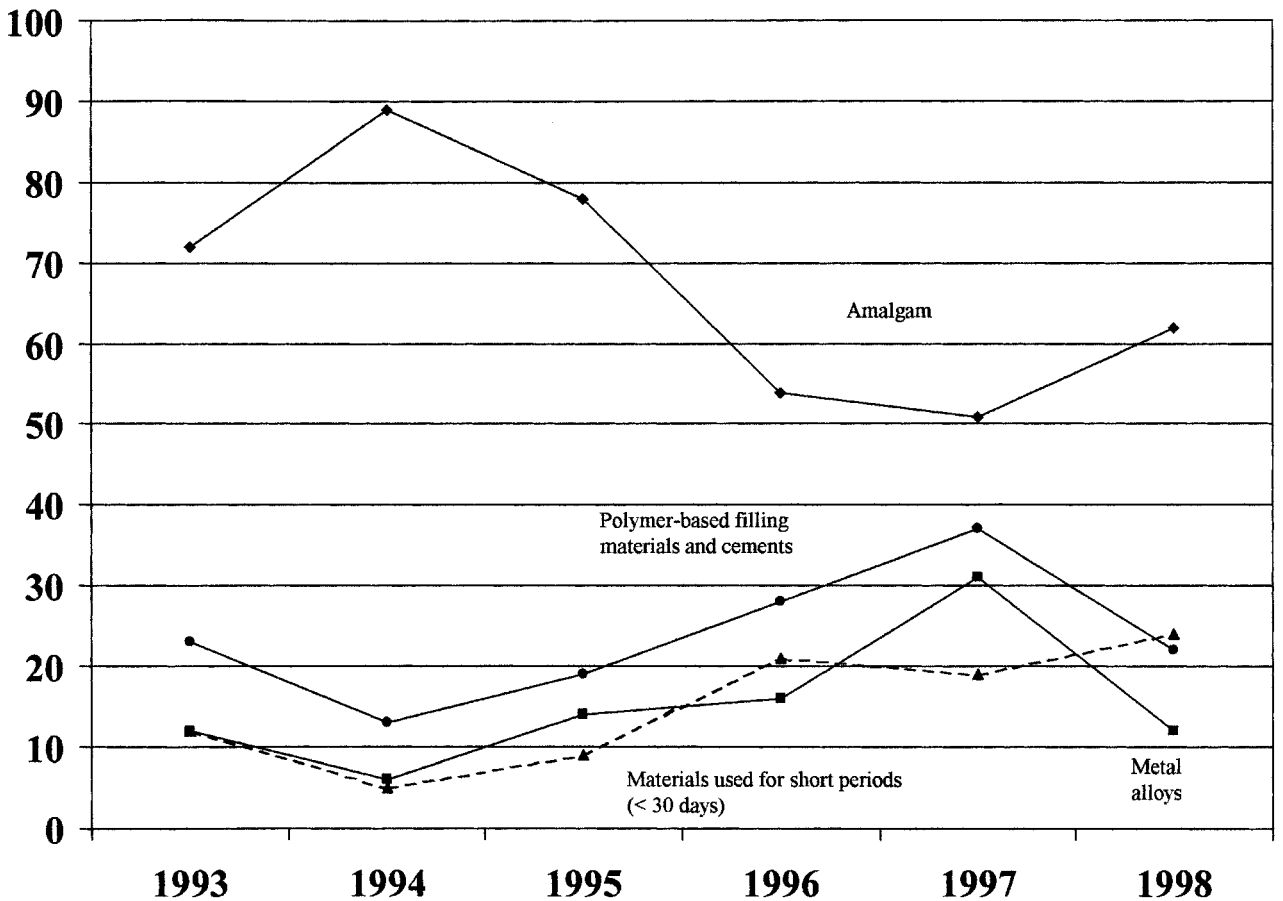

Fig. 4. The type of material involved in the notifications (percentage for each year) to The Registry of The Adverse Reaction Unit in Bergen from 1993 to 1998. (The numbers are presented with kind permission from The Adverse Reaction Unit in Bergen.)

Dental prosthetic treatment and contact allergy

Allergies to metals are quite common, and the most striking finding is the high frequency of Ni allergy in women. Twenty per cent of the patients in one dermal clinic were positive to Ni by patch testing (42). It is unusual for patients to have adverse reactions against Ni, Pd, or Au from dental biomaterials. The reaction may or may not be evident as a local stomatitis (43). Only some 10 cases of clinical contact allergy in dermis or mucous membranes had been described in the literature until the beginning of the 1990s (44). Björkner et al. (45) found a surprisingly high percentage of positive patch tests against gold sodium thiosulfate in a population of contact dermatitis patients (that is, 8%). The clinical relevance of positive patch tests against Au linked to oral or dermal symptoms has not been clarified. However, the frequency of Au allergy in patients with oral gold restorations has been found to be quite high (46). Patients with Au allergy do not necessarily react to contact eczema beneath gold jewelry, because gold salts are not made from metallic gold on the skin (44). Gold salts are a prerequisite to give contact allergy in sensitized patients.

Reactions against pulp

After the completion of prosthetic therapy on vital teeth, about 15% need endodontic treatment (47). This situation may result from exposure of dentin in the initial process but also because of reactions from pulp after the cementation of the restoration. Autopolymerized resins may result in a pulpal damage (48). Resins are degraded in the oral cavity, and organic compounds are released, in addition to metallic ions from filler particles. Using cultured cells, it has been possible to show that the monomers are cytotoxic (49). Pulpal cell damage may occur when a close relationship exists between the pulpal cells and the monomers BisGMA, UEDMA, and TEGDMA. The cytotoxic effect due to glass-ionomer cements has been shown to result from the content of the organic acids polyacrylic acid and polyitaconic acid. Potential biological effects from resin-modified cements are in

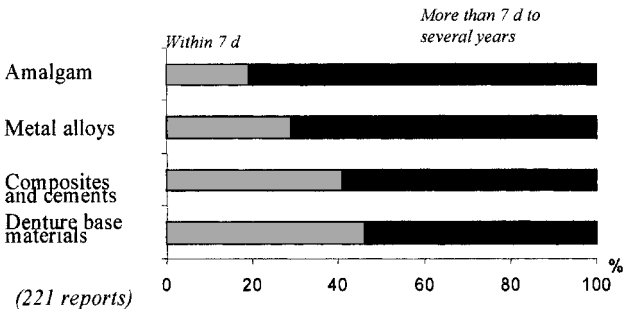

Fig. 5. The time recorded between the use of the material and the appearance of the reaction. Based on the basis of 221 reports to The Registry of The Adverse Reaction Unit in Bergen from 1993 to 1996. (The numbers are presented with kind permission from The Adverse Reaction Unit in Bergen.)

Table 1. Results from patch tests during 1995–97*

	Tested as positive (patch test)	Tested as negative (patch test)	Total
Amalgam	18	177	195
Gold/palladium* alloys	59	138	197
Components from polymer-based materials	22	171	193
Chromium/cobalt	37	159	196
Nickel	59	139	198

* The numbers are presented with kind permission from The Adverse Reaction Unit in Bergen.

accordance with the biological effects from resins and glass-ionomer cements (50, 51).

Frequency of adverse reactions

The frequency of adverse reactions in dentistry has been described by Kallus & Mjør (52) and, in addition, in reports from Jacobsen & Hensten-Pettersen (53, 54). They reported the frequency of adverse reactions in different types of dental treatment and concluded that, in general, adverse reactions in dentistry occur in 1.4 per 1000 patients. Orthodontic, periodontic, and prosthodontic treatment showed a higher frequency of adverse reactions, with orthodontics being the highest (54). Adverse reactions from prosthodontic treatment were found in 2.5 per 1000 patients (Fig. 2).

Registration of adverse reactions

To obtain true values for the frequency of adverse reactions from dental biomaterials in Norway, an Adverse Reaction Unit was established at the Dental School in Bergen in 1993. In Sweden a similar system was established in 1996, and in England in 2000. Australia has also been interested in establishing similar systems.

The Adverse Reaction Unit in Bergen receives patients from medical practitioners and dentists when they suspect adverse reactions from dental biomaterials (Fig. 3).

At the end of 1998 The Adverse Reaction Unit had received 777 notifications about perceived adverse reactions from dental biomaterials (55). It is possible that the number of adverse reactions to dental treatment is underestimated. The eastern part of Norway, with 50% of the total population, accounted for only 17% of the reports in 1996 and only 12.5% in 1997. Dentists submitted 80% of the reports, and medical practitioners 20%.

From 1994 until 1997 there was a tendency towards fewer notifications about filling materials. However, reports about prosthetic treatment are on the increase (Fig. 4). Most of the reports deal with objective reactions. These reactions may be local and topographically related (for example, lichenoid reactions) or general reactions presented as skin eruptions or other general reactions. With regard to groups of materials, the tendency in recent years is towards an increased number of notifications about amalgam. However, it is important to stress that perceived reactions are reported.

Materials for short-duration (<30 days; for example, temporary crowns) and temporary use (<1 h; for example, impression materials) are often related to early objective reactions. With regard to more permanent materials (>30 days) a difference exists with regard to the reactions. Amalgam and, in some respects, other alloys have been associated with perceived reactions for a long time. Reactions from resin materials initiate more rapidly (Fig. 5).

The main task of The Adverse Reaction Unit in Bergen is adverse reaction registration in The Norwegian Registry, medical and dental examination of the patients, and public information. There is cooperation with medical expertise. Patch testing is the most frequently used complementing examination. More than 60% of the referred patients were tested in 1995, using this method, and more than 40% had a positive reaction, such as contact allergy.

The Unit gives recommendations and provides advice with regard to treatment after the patient examination.

Frequency of contact allergy

Many reports exist about local or systemic allergy reactions from partial dentures containing, for example, Cu (56).

It has been considered that Ni, Cr, and Co are often involved in the production of metal allergies arising from prosthetic treatment (3). This is probably because of the formation of stable bonds between the metal and proteins (41). Palladium in Au—Ag–Pd alloys seems to be a weaker allergen than Hg or Ag–Sn–Hg amalgams or Ni, Cr, or

Co in other alloys. Persons who are sensitive to Ni are nearly always allergic to Pd (20).

Data from The Adverse Reaction Unit in Norway in 1995, 1996, and 1997 have shown that among metals from prosthetic restorations Ni and Au/Pd allergies were the most frequent, and thereafter Co/Cr allergy (Table 1).

The frequency of Ni, Cr, Au, and Pd allergy seems to be higher in patients with subjective symptoms connected to dental materials than in a control group (57). Data from the last report support an association between Ni, Au, and Pd allergy because these allergies often exist together in dental patients.

Occupational exposure

The Swedish Adverse Reaction Register in Umeå was established in 1996. The annual reports for 1996 and 1997 on registration are divided into a patient group and a personnel group. Of the 223 reports in 1997, 20% came from dental personnel. This was a decrease from 1996 (41% of 252 reports). However, 1996 was the first year of reporting, and an accumulation may be assumed for these data. In 1998 only 11% of the reports were from dental personnel (58). With regard to the etiology of the reports, dermal reactions from composites/bonding materials and latex gloves predominate. None of the adverse reactions in dental personnel from 1997 were related to amalgam. In the personnel group 52% were traced to be probable in 1997 but only 30% of the patient reports. A higher percentage in the personnel group may have resulted from the fact that most of the individuals had a medical examination.

Dermal reactions seem to be the most frequent occupational hazard among dental personnel. Self-reported dermal reactions in dental personnel appear to be very high—that is, 44.4% (59). Reports from the Finnish Register for Occupational Hazards show that the number of cases of contact allergy among dental personnel increased from 22 in the years 1982–84 to 95 in the years 1992–94 (60). The numbers may be considered to be small; nonetheless, similar increases for the years 2002–04 may give 410 cases. Wallenhammar et al. (61) conclude that dentistry is a high-risk occupation for hand eczema. This is why it has been recommended to use acrylic products and gloves, which have been shown to result in lower occupational hazards. It is also necessary to produce better product declarations and to use 'non-touch methods' in clinical dentistry. However, a recent report on occupational adverse reactions (62) states that the true prevalence of contact allergy to acrylic resins in dentists is not known in either Sweden or Denmark.

Final comments

The release of substances from prosthetic materials is a prerequisite for the occurrence of adverse reactions. Research on the release of components from prosthetic materials is scanty. In addition, a common understanding of the concept of adverse reactions from dental materials does not exist. Uncertainty also exists about which type of general symptoms results from dental materials. A high degree of uncertainty is also associated with the methods that have been used to ascertain toxic effects from dental materials. Nevertheless, contact allergy may be revealed by patch tests. However, we do lack much knowledge about the process of sensibilization by contact allergy resulting from dental materials. Objective and subjective oral symptoms in contact allergy seem to be difficult to classify.

This is the reason why the frequency and type of adverse reactions resulting from dental treatment, including prosthetic treatment, are uncertain. On the basis of current methods contact allergy is the major adverse reaction from prosthodontic biomaterials.

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Received for publication 2 January 2001
Accepted 11 June 2001