

OCCUPATIONAL HAZARDS OF ACRYLATE BONE CEMENT IN ORTHOPAEDIC SURGERY

Since the beginning of this century, and particularly since the 1940's, a large number of synthetic plastics have been developed for commercial use. Several of these plastics are used in medicine, and big plastic industries now have special divisions for the development of medical plastics.

However, many types of plastics in industry may cause general toxic effects and local skin disorders, mainly allergic contact eczema, in workers and consumers. Plastics used in medicine may harm medical personnel and patients.

Methylmethacrylate (MMA) was one of the first monomer plastics to be used in medicine, notably in denture materials in the 1940's. In the early 1950's, it was reported to cause allergic contact hand eczema in dentists and dental technicians, and, more rarely, to cause denture sore mouth in patients (Calnan & Stevenson 1963). MMA was used in hip prostheses, paraspinal acrylic inlays, skull reconstruction etc. in the 1950's (Charnley 1972). In 1971, acrylic bone cement was accepted by the Food and Drug Administration in the USA for use in the stabilization of hip prostheses. Since the beginning of the 1970's, there have been reports on allergic contact eczema due to exposure to acrylic bone cement in orthopaedic surgeons (Pegum & Medhurst 1971, Fisher 1974).

All types of acrylic plastics are based on acrylic acid ($\text{CH}_2 = \text{CH} - \text{COOH}$) with the essential reactive vinyl-group, $\text{CH}_2 = \text{CH}-$. The low molecular monomers, e.g. MMA, polymerize to high molecular polymers. The polymerization is induced by an initiator system with or without heat; some initiator systems are combined with UV-light. Many of the monomers, additives and degradation products of polymers are potential

sensitizers, but polymers are not. Benzoylperoxide, a common catalyst for MMA, is a sensitizer. Inhibitors are present in the MMA monomer to prevent self-polymerization at storage. These chemicals are also sensitizers. However, when exposure to MMA products induces sensitization, this is rarely due to the additives. Other sensitizing acrylates can also be added to the MMA.

The liquid part of hip bone cement contains MMA and an inhibitor, and the powder contains polymethylmethacrylate and benzoylperoxide. The MMA is polymerized at room temperature but the chemical reaction is of the exothermic type and the temperature is increased. The hardening takes 10-15 min. The polymerization is not, however, complete. Thus, monomers are present in the hardened cement for some time.

MMA is a powerful lipid solvent and dissolves rubber. It penetrates rubber gloves in a few minutes. It should be pointed out that the penetration of acrylates through gloves continues after the direct contact has ceased. The penetration was shown by patch testing *in vivo* and by *in vitro* experiments already in the first report on hand eczema in 1971 and has since been shown in other experiments (Pegum & Medhurst 1971, Fries et al. 1975). In the article by Waegemaekers et al. (p. 790 in this issue of *Acta Orthopaedica Scandinavica*), the penetration was demonstrated *in vitro* by exact measurements. The authors state that "a better protective material is urgently needed". However, the *in vitro* penetration studies are not necessarily relevant to clinical conditions as they were performed with concentrated MMA liquid.

Medical staff can easily avoid contact with

MMA as a liquid, as the cement is used when no longer sticky. To the naked eye, the rubber gloves do not then show any change. Probably minimal amounts of MMA penetrate the outer gloves from the cement, although the gloves contaminated by cement are used for up to 30 min.

Before contact eczema of an allergic type can be elicited, contact allergy must previously be induced by exposure. Strong sensitizers have the ability to induce allergy in 5 days by one single application on skin, but commonly repeated exposures are necessary, sometimes for years, before the allergy is induced. Therefore, an orthopaedic surgeon cannot be safe even after years of exposure. However, according to predictive guinea-pig tests, MMA is a medium sensitizer.

In sensitized individuals, contact eczema is elicited by a single exposure of a sufficient amount of the sensitizer, mostly micrograms. The eczema is limited to contact sites and therefore, as a rule, to the volar sites and fingertips of orthopaedic personnel. The eczema is characterized by itching, erythema, and often vesicles. Some surgeons develop contact eczema of an irritant type without contact allergy, and the condition is then characterized by dryness and fissuring of the fingertips. In some cases it has been reported that the allergic eczema was accompanied by paraesthesia of the fingertips with burning sensations, tingling, and slight numbness (Fisher 1979). The condition was reported to persist for several weeks and in some cases for months.

The frequency of contact eczema due to bone cement is not known. In 1983, inquiries were made among dermatologists in Europe specializing in contact eczema. Only a few cases had been seen over the last 5 years. Since the reports on hand eczema, mixing of bone cement has apparently been performed more carefully and double gloves are used.

Inhaled MMA may cause headache and irritation of the eyes and the respiratory tract.

Other medical personnel handling MMA, e.g. making dentures, extremity prostheses or hearing aids, are often more exposed than orthopaedic personnel, and some develop eczema.

Suspected side-effects of bone cement in pa-

tients, such as prosthesis rejection or sudden death, have been reported. This problem will not be discussed here.

As compounds other than MMA may cause allergic reactions in hip surgery, it is of great importance that medical personnel with hand eczema suspected to be caused by bone cement are properly examined in order to avoid relapses. A sensitized surgeon can usually continue to use bone cement in hip surgery.

Patch testing (48 h test for delayed allergy) should be performed with the liquid and powder (not mixed) components of the bone cement, methylmethacrylate (MMA), hydroquinone, N,N-dimethyl-paratoluidine, benzoylperoxide, rubber gloves, standard rubber chemicals, and antibiotics (e.g. gentamycin).

A prick test (20 min for immediate allergy) should be performed with natural rubber latex, thiuram sulfides and zincdiethyldithiocarbamate.

The consequences and precautions taken to avoid relapses depend on the contact allergy induced. Thus, MMA can be present in sensitizing form in dentures, hearing aids and artificial fingernails; and benzoylperoxide in topical acne medicaments. The rubber chemicals in gloves occur in many other rubber objects.

With the following preventive measures, it is possible to diminish or almost eliminate the risk of skin effects from bone cement in surgical personnel.

- The packages of the liquid and powder should be of a disposable type.
- The mixing procedure should take place in a fume hood.
- The mixing should be done with utensils, without glove contact, until the material is no longer sticky.
- The surgeon and other personnel with contact should use two layers – if possible three layers – of gloves during handling of the cement, and then immediately remove all the gloves.
- Utensils used for mixing, remnants of bone cement and gloves should be destroyed. This is necessary also for the protection of the post-operative working personnel. The broken bone cement liquid ampoule is particularly risky.

In order to ensure better protection in the future,

it is important to develop gloves which are not penetrated by MMA or other possible acrylates present in bone cement, to design better equipment for mechanical mixing and packing into the joint and to produce a less sensitizing cement.

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