

Methacrylate and acrylate allergy in dental personnel

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Background: Methacrylates are important allergens in dentistry.

Objective: The study aimed to analyse patch test reactivity to 36 acrylic monomers in dental personnel in relation to exposure.

Methods: We reviewed the test files at the Finnish Institute of Occupational Health from 1994 to 2006 for allergic reactions to acrylic monomers in dental personnel and analysed the clinical records of the sensitized patients.

Results: 32 patients had allergic reactions to acrylic monomers: 15 dental nurses, 9 dentists, and 8 dental technicians. The dentists and dental nurses were most commonly exposed to 2-hydroxyethyl methacrylate (2-HEMA), triethyleneglycol dimethacrylate (TREGDMA), and 2,2-bis[4-(2-hydroxy-3-methacryloxypropoxy) phenyl]propane (bis-GMA). 8 dentists and 12 dental nurses were allergic to 2-HEMA. The remaining dentist was positive to bis-GMA and other epoxy acrylates. The remaining 3 dental nurses reacted to diethyleneglycol diacrylate (DEGDA) or triethyleneglycol diacrylate (TREGDA), but not to monofunctional and multifunctional methacrylates. Our dental technicians were mainly exposed and sensitized to methyl methacrylate (MMA) and ethyleneglycol dimethacrylate (EGDMA). 1 technician reacted only to 2-HEMA, and another to ethyl methacrylate (EMA) and ethyl acrylate (EA).

Conclusions: 2-HEMA was the most important allergen in dentists and dental nurses, and MMA and EGDMA in dental technicians. Reactions to bis-GMA, DEGDA, TREGDA, EMA and EA were relevant in some patients.

Key words: diethyleneglycol diacrylate; ethyl acrylate; ethyleneglycol dimethacrylate; ethyl methacrylate; methyl methacrylate; triethyleneglycol diacrylate; triethyleneglycol dimethacrylate; 2-hydroxyethyl methacrylate; 2,2-bis[4-(2-Hydroxy-3-methacryloxypropoxy)phenyl] propane.
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Acrylic monomers – acrylates, methacrylates, urethane acrylates, and epoxy acrylates – are used in dentistry in prostheses, dental composite resins, dentin bonding materials, and glass ionomers (1). Acrylic monomers, especially methacrylates, have been among the most common occupational contact allergens in dental personnel in Finland (2, 3). In the 1990s, contact allergy to methacrylates increased considerably in this professional field (4). In previous studies, dental personnel have usually been the largest professional group to suffer from occupational acrylic monomer allergy (5–7).

Nowadays, acrylic monomers are included in several different commercial patch test series: there are separate series for dental patients, dental

staff, artificial nails, and printing. At the Finnish Institute of Occupational Health (FIOH) a large patch test series of acrylic monomers (the so-called Methacrylate Series) has been used on all of the patients irrespective of their occupation. We wanted to analyse the pattern of allergic reactions to acrylic monomers in relation to exposure in our patients working as dentists, dental nurses and, dental technicians.

Materials and Methods

We reviewed FIOH test files from September 1994 to August 2006 for allergic reactions in our Methacrylate series. The patch tests were performed using the Finn Chambers (Epitest, Tuusula,

Finland) according to the recommendations of the International Contact Dermatitis Research Group. We read the tests twice or 3 times [on D2-(D3)-D4/5/6] depending on the day of their application. Our series is based on the allergens provided by Chemotechnique (Vellinge, Sweden), but several Trolab's (Hermal, Reinbek, Germany) preparations and in-house test substances have also been used. The composition of the series varied during the study period, and different test substances were tested on a different number of patients. The different test substances are given in Table 1 (see also footnote). In addition, triethyle-

neglycol diacrylate (TREGDA, 0.1% petrolatum, Chemotechnique) was tested in our standard series during the same time period.

In the present study, we included only dentists, dental nurses, and dental technicians with allergic reaction (+/+/+/+) to at least 1 acrylic monomer in our Methacrylate Series and analysed their clinical records for symptoms, exposure [safety data sheets (SDSs) /the results of the chemical analyses of their own products], patch test reactions to their own acrylic products, and diagnosis.

During the study period (between September 1994 and August 2006), a total of 473 patients

Table 1. The reactions and exposure to various acrylic monomers in 9 dentists, and the abbreviations, concentrations in petrolatum (pet.) and providers of the test substances which gave allergic reactions in at least 1 of the patients in the whole study group. The test substances, which gave no allergic reactions in dental personnel are listed in the footnote.

Patient number		1	2	3	4	5	6	7	8	9
Year of investigation		1995	1995	1997	2000	2000	2001	2002	2004	2004
Test substance	Concentration provider (%)									
Methyl methacrylate	2, C/T	+++ (C)	+	+	+	+	+	+	+	+
Ethyl methacrylate	0.1, C	+++	++	+	+	?	+	?	+	+
N-Butyl methacrylate	2, C	+	—	—	—	—	—	—	—	—
2-Hydroxyethyl methacrylate	1, T	+++ ^a	+++ ^b	+++ ^a	+++ ^a	++	+++ ^a	+++ ^{a, c}	—	++
2-Hydroxypropyl methacrylate	2, C	+++	++	++	++	++	++	+	—	++
Ethyleneglycol dimethacrylate	2, T	++	++ ^b	++	++	++	+	+++ ^c	—	++
Triethyleneglycol dimethacrylate	2, T	++	++ ^b	—	++ ^a	—	— ^a	++ ^{a, c}	—	— ^a
1,4-Butanediol dimethacrylate	2, C	++	—	?	—	—	—	— ^c	—	— ^b
Urethane dimethacrylate	2, C	+	—	—	—	—	—	— ^c	—	—
Tetrahydrofurfuryl methacrylate	2, C	++	+	—	?	—	—	++ ^c	—	—
N,N-Dimethylaminoethyl methacrylate	0.2, C	NT	NT	NT	— ^c	— ^c	NT	— ^c	—	—
Ethyl acrylate	0.1, C	—	++ ^b	?	+	—	—	?	—	—
Butyl acrylate	0.1, C	—	—	—	—	—	—	—	—	—
1,6-Hexanediol diacrylate	0.1, C	—	—	—	—	—	—	— ^c	—	—
Diethyleneglycol diacrylate	0.1, C	—	—	—	—	—	—	?	—	+
Tripropyleneglycol diacrylate	0.1, C	—	—	—	—	—	—	—	—	—
Triethyleneglycol diacrylate (in the standard series)	0.1, C	—	—	—	—	NT	—	—	—	—
Trimethylolpropane triacrylate	0.1, C	—	—	—	—	—	—	—	—	—
Pentaerythritol triacrylate	0.1, C	—	—	—	—	—	—	—	—	—
Urethane diacrylate, aromatic	0.05, C	—	—	—	—	—	—	—	—	—
Ethyl cyanoacrylate	2, O	—	—	—	—	—	—	—	—	—
2,2-bis[4-(Methacryloxyethoxy)phenyl]propane	1, C	—	—	—	—	—	—	—	+	—
2,2-bis[4-(2-Hydroxy-3-methacryloxypropoxy)phenyl]propane	2, T	— ^a	— ^a	—	— ^a	—	— ^a	— ^{a, c}	+	— ^a
Etoxyated methacrylate of bisphenol A (bis-EMA)	2, O	NT	NT	NT	?	—	—	—	+	—
Glycidyl methacrylate	0.1, O	NT	NT	—	+	—	—	—	—	—
Epoxy diacrylate (epoxy acrylate)	0.5, C	—	—	—	—	—	—	—	+	—
Epoxy resin (in the standard series)		—	— ^c	—	— ^c	— ^c	—	—	++	—
Own methacrylate product		+++	++	++	NT	NT	++	NT	NT	+

There were no allergic reactions to (all in pet.) 2-ethylhexyl acrylate (2-EHA; 0.1% C), 1,6-hexanediol diacrylate (HDDA; 0.1% C), ethoxyethyl acrylate (EEA; 0.1% O), Phenoxyethyl acrylate (PEA; 0.1% O), isobornyl acrylate (IBA; 0.1% O), 1,4-butanediol diacrylate (BUDA; 0.1% C), dipropylene glycol diacrylate (DPGDA; 0.1% O), oligotriacrylate 480 (OTA 480; 0.1% C), aliphatic urethane diacrylate (al-UDA; 0.1% C), 2,2-bis[4-(Methacryloxy)phenyl]propane (bis-MA; 2% C) and N,N-methylenebisacrylamide (MBAA; 1% C). C, Chemotechnique, Vellinge, Sweden; T, Trolab, Hermal, Reinbeck, Germany; O, in-house preparation.

^aMentioned in the SDS of subject's own products; NT, not tested.

^bDetected in the analysis of subject's own products.

^cTested elsewhere before the investigation at Finnish Institute of Occupational Health.

were tested with the Methacrylate Series. This included 55 dentists (12%), 192 dental nurses (41%) and 11 dental technicians (2%). The number of dental nurses was large, because 86 dental nurses had been investigated in an epidemiological study (2) possibly for milder indications than in normal circumstances. Of the 473 patients tested with the Methacrylate Series, 32 had at least 1 allergic reaction and worked in dentistry: 9 of them were dentists (Patients number (no.) 1–9 in Table 1), 15 dental nurses (Patients no. 10–24 in Table 2), and 8 dental technicians (Patients no. 25–32 in Table 3). 19 patients were tested with some methacrylate products they used in their jobs: 17 had allergic reactions and 2 had doubtful reactions (?+) only (Tables 1–3). In 6 cases chem-

ical analysis of the particular methacrylate product(s) used by the subject at work was performed. In 6 cases there were no SDSs in the files.

Results

The most commonly positive allergens were 2-hydroxyethyl methacrylate (2-HEMA) and ethyleneglycol dimethacrylate (EGDMA) both in 24 cases (75%), and 2-hydroxypropyl dimethacrylate (2-HPMA) in 23 cases (72%). Ethyl methacrylate (EMA) was positive in 9 cases (28%), methyl methacrylate (MMA) in 8 (25%), and tetrahydrofurfuryl methacrylate (THFMA) and ethyl acrylate (EA) were both positive in 7 cases (22%). Less common allergens were diethyleneglycol diacrylate

Table 2. The reactions and exposure to the same acrylic monomers in 15 dental nurses (Patients no. 10–24)

Patient number	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Year of investigation	1995	1995	1996	1996	1997	1997	1998	1998	1998	1998	1998	99	2001	2002	2002
Test substance															
MMA	– (C)	– (C)	++ ^b	++ ^b	–(C)	–(C) ^a	– (T)	– (T)	– (T)	– (T)	– (T)	– (T)	– (C, T)	– (C, T)	– (C, T) ^a
EMA	++	–	++	++	?+	–	–	?+	–	–	–	–	–	–	–
BMA	–	–	+	–	–	–	–	–	–	–	–	–	–	–	–
2-HEMA	++ ^a	++ ^a	++ ^a	++ ^{b,c}	++ ^a	++ ^a	++ ^a	++	–	++ ^a	++	+	++ ^{a,b}	–	– ^a
2-HPMA	++	++	++	++	++	?+	+	++	–	++	++	+	++	–	–
EGDMA	++	++	+++ ^b	+++ ^{b,c}	+	+	–	+++ ^b	–	++	++	+	++ ^b	–	–
TREGDMA	?+ ^a	– ^a	++ ^b	++ ^b	– ^a	– ^a	– ^a	–	– ^a	–	–	–	– ^a	–	– ^a
BUDMA	–	?+	NT	++ ^b	–	–	–	–	–	–	–	–	–	–	–
UEDMA	–	– ^a	+	++ ^b	–	–	–	–	–	–	–	–	–	–	– ^a
THFMA	–	–	++	++ ^b	–	–	–	–	–	–	–	–	–	–	–
DMAEMA	NT	NT	NT	++ ^b	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	–
EA	–	–	++	++	–	–	–	–	–	+	–	–	–	–	–
BA	–	–	+	–	–	–	–	–	–	–	–	–	–	–	–
HDDA	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
DEGDA	–	–	–	+	–	–	–	–	++	–	+	–	–	–	+
TPGDA	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–
TREGDA(standard series)	–	–	NT	+	–	–	–	–	++	–	–	–	–	+	–
TMPTA	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–
PETA	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–
ar-UDA	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–
ECA	–	–	–	–	–	–	+	–	–	–	–	–	–	–	–
BIS-EMA	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
BIS-GMA	– ^a	– ^a	– ^{a,b}	– ^c	– ^a	– ^a	– ^a	–	– ^a	–	–	–	– ^a	–	– ^a
EBADMA	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT?	NT	–	+	–
GMA	NT	NT	NT	NT	NT	–	–	–	–	–	–	–	–	–	–
EDA	–	–	–	–	–	–	–	–	?+	–	–	–	–	–	–
Epoxy resin (standard series)	–	–	– ^b	– ^b	–	–	–	–	–	–	–	–	–	–	–
Own methacrylate product	++	++	++	++	NT	NT	+	NT	NT	NT		?+	++	NT	NT

Concentrations and providers for the test substances and the content of the whole Methacrylate Series see Table 1 and its footnotes. C, Chemotechnique, Vellinge, Sweden; T, Trolab, Hermal, Reinbeck, Germany; NT, not tested; MMA, methyl methacrylate; EMA, ethyl methacrylate; BMA, *N*-Butyl methacrylate; 2-HEMA, 2-Hydroxyethyl methacrylate; 2-HPMA, 2-Hydroxypropyl methacrylate; EGDMA, ethyleneglycol dimethacrylate; TREGDMA, triethyleneglycol dimethacrylate; BUDMA, 1,4-Butanediol dimethacrylate; UEDMA, urethane dimethacrylate; THFMA, tetrahydrofurfuryl methacrylate; DMAEMA, *N,N*-dimethylaminoethyl methacrylate; EA, ethyl acrylate; BA, butyl acrylate; HDDA, 1,6-Hexanediol diacrylate; DEGDA, diethyleneglycol diacrylate; TPGDA, tripropylene glycol diacrylate; TREGDA, triethyleneglycol diacrylate; TMPTA, trimethylolpropane triacrylate; PETA, pentaerythritol triacrylate; ar-UDA, Urethane diacrylate, aromatic; ECA, ethyl cyanoacrylate; 2,2-bis[4-(Methacryl-oxyethoxy)phenyl] propane (bis-EMA); BIS-GMA, 2,2-bis[4-(2-Hydroxy-3-methacryl-oxypropoxy)phenyl] propane; EBADMA, etoxylated methacrylate of bisphenol A (bis-EMA); GMA, glycidyl methacrylate; and EDA, epoxy diacrylate (epoxy acrylate).

^aMentioned in the SDS of subject's own product.

^bTested elsewhere than at Finnish Institute of Occupational Health.

^cDetected in the analysis of subject's own product.

Table 3. The reactions and exposure to the same acrylic monomers in 8 dental technicians (Patients no. 25–32)

Patient number	25	26	27	28	29	30	31	32
Year of investigation	1995	1998	1999	1999	2000	2002	2002	2002
Test substance								
MMA	– (C) ^a	++ (T) ^a	– (T) ^{a,c}	?+ (T) ^{a,b,c}	– (T,C) ^{b,c}	+ (C)	?+(C) ^a – (T)	+ (T,C) ^a
EMA	–	++	–	+	–	–	–	–
BMA	–	?+	–	–	– ^c	–	–	–
2-HEMA	++	++	–	?+	++ ^c	+	?+	?+
2-HPMA	–	++	–	?+	++	+	?+	+
EGDMA	?+	++ ^a	+ ^c	?+ ^{a,c}	+ ^c	++ ^d	+ ^a	?+
TREGDMA	?+	+ ^a	–	– ^{a,c}	– ^c	–	–	–
BUDMA	–	+	–	–	–	–	–	–
UEDMA	–	– ^a	–	–	–	–	–	–
THFMA	–	+	–	–	–	–	–	–
DMAEMA	NT	NT	NT	NT	NT	–	–	–
EA	–	++	–	+	–	?+	–	–
BA	–	?+	–	–	–	–	–	–
HDMA	–	–	–	–	–	–	–	–
DEGDA	–	?+	–	–	–	–	–	–
DPGDA	NT	NT	NT	NT	–	–	–	–
TPGDA	–	–	–	–	–	–	–	–
TREGDA (standard series)	–	–	–	–	–	NT	–	–
TMPTA	–	–	–	–	–	–	–	–
PETA	–	–	–	–	–	–	–	–
ar-UDA	–	–	–	–	–	–	–	?+
ECA	–	–	–	–	–	–	–	–
BIS-EMA	–	–	–	–	–	–	–	–
BIS-GMA	–	– ^a	–	–	–	–	–	–
EBADMA	NT	NT	NT	NT	–	–	–	–
GMA	NT	–	–	–	–	–	–	–
EDA	–	–	–	–	–	–	–	?+
Epoxy resin (standard series)	–	–	–	–	–	– ^d	–	–
Own methacrylate product	++	NT	++	+	+	++	?+	+

Concentrations and providers for the test substances and the content of the whole Methacrylate Series see Table 1 and its footnotes. C, Chemotechnique, Vellinge, Sweden; T, Trolab, Hermal, Reinbeck, Germany; NT, not tested; MMA, methyl methacrylate; EMA, ethyl methacrylate; BMA, *N*-Butyl methacrylate; 2-HEMA, 2-Hydroxyethyl methacrylate; 2-HPMA, 2-Hydroxypropyl methacrylate; EGDMA, ethyleneglycol dimethacrylate; TREGDMA, triethyleneglycol dimethacrylate; BUDMA, 1,4-Butanediol dimethacrylate; UEDMA, urethane dimethacrylate; THFMA, tetrahydrofurfuryl methacrylate; DMAEMA, *N,N*-Dimethylaminoethyl methacrylate; EA, ethyl acrylate; BA, butyl acrylate; HDMA, 1,6-Hexanediol diacrylate; DEGDA, diethyleneglycol diacrylate; TPGDA, tripropylene glycol diacrylate; TREGDA, triethyleneglycol diacrylate; TMPTA, trimethylolpropane triacrylate; PETA, pentaerythritol triacrylate; ar-UDA, Urethane diacrylate, aromatic; ECA, ethyl cyanoacrylate; 2,2-bis[4-(Methacryl-oxethoxy)phenyl] propane (bis-EMA); BIS-GMA, 2,2-bis[4-(2-Hydroxy-3-methacryl-oxypoxy)phenyl] propane; EBADMA, etoxylated methacrylate of bisphenol A (bis-EMA); GMA, glycidyl methacrylate; and EDA, epoxy diacrylate (epoxy acrylate).

^aMentioned in the SDS of subject's own product.

^bThe concentration of MMA in the test substance was 0.52% MMA (should be 2%).

^cDetected in the analysis of subject's own product.

^dTested elsewhere than at Finnish Institute of Occupational Health.

(DEGDA) with 5 reactions, triethyleneglycol dimethacrylate (TREGDMA) with 4 reactions, TREGDA, 1,4-butanediol methacrylate (BUDMA) and urethane dimethacrylate (UEDMA) each with 3 reactions. There were no reactions to the 9 test preparations listed in the footnote of Table 1.

The clinical records of 1 dental nurse (no. 20) were not found. All of the other 31 patients had hand dermatitis, and 25 of them had had fingertip dermatitis typical of methacrylate allergy. The methacrylate allergy was considered occupational in all of the 31 patients whose clinical records were available. We present the available exposure data in Tables 1–3.

Discussion

It is common that methacrylate allergic patients have simultaneous allergic reactions to several methacrylate test substances, although they have probably not been exposed to all of the positive compounds. Some of the multiple reactions probably derive from cross-allergy between acrylic monomers. However, it is difficult to establish an individual's history of exposure to various acrylic monomers in dental materials, because the patients will have used various different products during their working life, dental products often contain many undeclared acrylic monomers, and differences probably occur between different

batches of the same product (8, 9). When commonly used dental restorative materials in the Finnish market were analysed, bonding materials most often contained 2-HEMA and bis-GMA, composite resins bis-GMA and TREGDMA, and glass ionomers 2-HEMA and trimethylolpropane trimethacrylate (9). In the same investigation SDSs proved to be unreliable: information about methacrylates was given in about half of the products that according to the analysis contained methacrylates and some methacrylic compounds given in the SDSs could not be detected (9). Impurities in patch test preparations may also have led to false interpretation of patch test results (10): for instance in the 1980s some technical grade raw materials were sometimes used in commercial test preparations (11).

2-HEMA and EGDMA gave the largest number of positive reactions in the present study. The same 2 allergens have been among the 3 most common allergens in all recent studies on occupational methacrylate allergy in dental personnel (3, 6, 7, 12–14). According to the SDSs, our dentists and dental nurses were mostly exposed to 2-HEMA, 2,2-bis[4-(2-hydroxy-3-methacryloxypropoxy)phenyl] propane (bis-GMA) and TREGDMA. Allergic reactions to TREGDMA were rare in relation to exposure. EGDMA, in turn, was often not mentioned in the SDSs of the dental restorative materials, but in 2 cases out of 3 chemical analysis showed EGDMA content in the tested products (0.4% and 5%; patients no. 2 and 13). These findings are similar to the previous comparisons of SDSs and chemical analyses of dental materials at FIOH (9, 15). In accordance with a larger study from Germany (13), our dental technicians most often reacted to EGDMA and 2-HEMA. In the present study, however, clearly positive reactions to these allergens were somewhat less common with the dental technicians than with the dentists and dental nurses. The SDSs and chemical analyses showed that our dental technicians were often exposed to EGDMA and MMA, but 2-HEMA was not mentioned in their SDSs, and analysis showed it only once (0.05% 2-HEMA in the analysis of a product of Patient no. 29). Animals sensitized to 2-HEMA or MMA often react to EGDMA (16). The frequent reactions to EGDMA in our dentists and dental nurses can derive from cross-allergy to 2-HEMA, but in our dental technicians even the reverse might be true.

2-HPMA was positive in 23 (72%) patients, but all of these patients also reacted to 2-HEMA (22 allergic reactions and 1 doubtful ?+ reaction). In animal studies, 2-HEMA has induced strong cross-reactions to 2-HPMA (16). In the present study, 2-HPMA was not mentioned in the SDSs

of our patients or detected in the analyses of their products. In a previous study by FIOH, HPMA was present as an impurity (0.3%) in 2 dental products, 1 bonding material, and 1 glass ionomer (9). Considering the large number of 2-HPMA reactions, we assume that most of them probably derive from cross-allergy to 2-HEMA.

MMA is an important ingredient in dental prosthetic work (13, 17), so it was not surprising that the dental technicians in the present study reacted to MMA more often than the dentists and dental nurses. Whenever dental technicians' SDSs were available, a mention of MMA could always be found. Although reactions to MMA may derive from cross-allergy to 2-HEMA (16), our results, in line with those of a recent Swedish study (14), strongly support the alternative that reactions to MMA result from true and separate sensitization. In 1999 at FIOH, a negative patch test reaction to MMA in a dental technician (Patient no. 27) despite strong positive reactions to her own MMA-containing products led to chemical analysis of the MMA test substance (2%), where the substance was found to contain only 0.5% MMA. If the concentration had been adequate, more allergic reactions to MMA would probably have been detected.

EMA was among the most common allergens in the present series, but the reactions to it were usually connected with reactions to other acrylic monomers, especially to MMA and EA. EMA was not declared in the SDSs or found in the chemical analyses in the present study, but in the previous study from FIOH, 2 bonding materials contained EMA as an impurity (1%) (9). Although true sensitization cannot be excluded, cross-allergy to MMA (18) is 1 possible explanation for the EMA reactions. 1 dental technician (no. 28) had the strongest reactions (+) to EMA, EA and his own MMA-containing product, and only doubtful reactions to MMA, 2-HEMA, 2-HPMA, and EGDMA. In this case the reaction to EMA ensured the diagnosis of methacrylate allergy, when the MMA test possibly failed because of the inadequately low concentration of 0.5%.

THFMA gave some positive reactions in accordance to other studies on dental methacrylates (3, 12, 14), but the reactions were usually connected with multiple reactions to a large number of other methacrylates. THFMA was not mentioned in the SDSs of our patients, or analysed in their products. It has been found in previous analyses of 2 adhesives at FIOH, but not in dental products (19). The reactions are best explained by cross-allergy to other methacrylates (20).

BUDMA was positive in some patients, but they had concomitant reactions to many other

methacrylates. According to chemical analyses, 2 dental technicians were exposed to BUDMA containing products (5–6%, Patients no. 28 and 29), but both of them were negative to BUDMA.

EA is a small molecule that occurred as an impurity in chemical analysis of various acrylic monomer patch test preparations at FIOH in 1993, and in this study in a dental composite resin of a dentist (0.9% EA in the analysis of a composite resin of Patient no. 2). Most of the positive reactions were in connection with reactions to MMA, 2-HEMA, and EGDMA, making cross-allergy a possible explanation.

We had 5 dental nurses and 1 dentist who had allergic reactions to acrylates DEGDA or TREGDA. 3 of them, all dental nurses (Patients no. 18, 23, and 24), did not have allergic reactions to commercial methacrylate test preparations. Reactions to these 2 acrylates have been reported in previous studies on dental personnel (7,21–23) in association with reactions to methacrylates, but they are not included in commercial patch test series of dental methacrylates. TREGDA and DEGDA are aliphatic organic diluents that were used earlier to some extent in dental composite resins to reduce the high viscosity of bis-GMA and to increase the degree of conversion. According to a representative of dental products in Finland, TREGDMA is nowadays probably the only diluent used for this purpose. All of the 3 dental nurses had hand eczema in the 1980s while working with dental acrylates, so it is possible that their contact allergy to TREGDA or DEGDA derives from that decade.

Only 2 of our patients reacted to epoxy acrylates. The first 1 was a dentist (Patient no. 8), and her reactions to bis-GMA, 2,2-bis[4-(methacryloxyethoxy)phenyl] propane (bis-EMA) and epoxy diacrylate probably derived from the 1980s when she had handled dental composite resins without protective gloves. The second patient (no. 23) was a dental nurse with hand dermatitis since the 1980s. In addition to several other acrylates, she reacted to ethoxylated dimethacrylate of bisphenol A, an in-house test substance for bis-EMA, which is a raw material for temporary crowns and bridges provided by a German manufacturer (24). She did not react to the commercial bis-EMA.

In the 1980s at FIOH, contact allergy to epoxy acrylates was found in 5 dental professionals, and it was always connected with reactions to diglycidyl ether of bisphenol A (DGEBA)-based epoxy resin (11, 22, 25). These cases and the patch tests of other epoxy allergic patients at FIOH indicated that exposure to DGEBA-epoxy resin results in cross-reactivity to epoxy acrylates and vice versa (8, 22). In an animal study from 1984, impurities

in commercial products of bis-GMA had high sensitizing capacity, and the presence of epoxy resin was a probable explanation to this (26). In 1991, dental restorative materials were analysed at FIOH, and small amounts (0.01–0.06%) of DGEBA-epoxy resin were present in all of the 7 dental restorative materials that contained bis-GMA. Although many dental composite resins still contain bis-GMA, contact allergy to it was rare in the present series, possibly because the products no longer contain sensitizing impurities or because the use of gloves prevents sensitization to this high-molecular-weight compound and its possible impurities.

Regarding urethane acrylates and methacrylates, we had 3 reactions to UEDMA and 1 reaction to aromatic urethane acrylate (ar-UDA). The UEDMA reactions were in patients (no. 1, 12, and 13) who reacted to a large number of methacrylates, whereas the reaction to ar-UDA was in a patient (no. 22) with reactions to several acrylates. UEDMA was mentioned in an SDS of 1 patient (no. 11), but this patient was not allergic to UEDMA or urethane acrylates. In previous analyses of dental restorative materials at FIOH, UEDMA was found in 2 bonding materials (2–29%) and 3 composite resins (8–15%). In dental workers, sensitization because of specific exposure to UEDMA is possible, but cross-allergy to other methacrylates is an alternative explanation for the reactions to the urethane compounds in this study.

The number of methacrylate allergic dental personnel referred to FIOH has decreased in the 2000s. This is possibly because of non-touch techniques and improved general awareness of the sensitizing properties of these chemicals. Many dental workers are also aware of the need to immediately change gloves if they notice any glove contact to methacrylate products. This is because of rapid permeation of low-molecular-weight methacrylates through common protective gloves (27).

2-HEMA was definitely the most important allergen in dentists and dental nurses. 2-HEMA was positive in 83% of our methacrylate/acrylate allergic patients in these 2 professions. The remaining 3 dental nurses reacted to TREGDA and DEGDA, and 1 dentist was positive to bis-GMA. Our dental technicians had handled MMA-containing products and exposure to EGDMA was also frequent. MMA and EGDMA would have uncovered the problem in the case of 6 of our 8 dental technicians: 1 of the remaining 2 cases reacted to 2-HEMA and the other to EMA and EA. 4 (13%) of our patients could not have been diagnosed with the allergens of the Dental Methacrylate Series of Chemotechnique or Trolab.

In conclusion, 2-HEMA was the most important allergen in dentists and dental nurses and EGDMA and MMA in dental technicians. Reactions to bis-GMA, DEGDA, TREGDA, EMA, and EA were relevant in some patients.

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