

Contact allergy to (meth)acrylates in the dental series in southern Sweden: simultaneous positive patch test reaction patterns and possible screening allergens

ANTHONY T. J. GOON, MARLÉNE ISAKSSON, ERIK ZIMERSON, CHEE LEOK GOH AND MAGNUS BRUZE

Department of Occupational and Environmental Dermatology, Lund University,
Malmö University Hospital, Malmö, Sweden

Contact allergy to dental allergens is a well-studied subject, more so among dental professionals than dental patients. 1632 subjects had been patch tested to either the dental patient series or dental personnel series at the department of Occupational and Environmental Dermatology, Malmö, Sweden. Positive patch tests to (meth)acrylate allergens were seen in 2.3% (30/1322) of the dental patients and 5.8% (18/310) of the dental personnel. The most common allergen for both groups was 2-hydroxyethyl methacrylate (2-HEMA), followed by ethyleneglycol dimethacrylate (EGDMA), triethyleneglycol dimethacrylate, and methyl methacrylate. 47 (29 dental patients and 18 dental personnel) out of these 48 had positive patch tests to 2-HEMA. All 30 subjects who had a positive reaction to EGDMA had a simultaneous positive reaction to 2-HEMA. One dental patient reacted only to 2,2-bis[4-(2-hydroxy-3-methacryloxypropoxy) phenyl]propane (bis-GMA). From our data, screening for (meth)acrylate contact allergy with 2-HEMA alone would have picked up 96.7% (29/30) of our (meth)acrylate-allergic dental patients and 100% (18/18) of our (meth)acrylate-allergic dental personnel. The addition of bis-GMA in dental patients would increase the pick-up rate to 100%.

Key words: allergic contact dermatitis; dental; (meth)acrylate; patch test; screening. © Blackwell Munksgaard, 2006.

Accepted for publication 28 May 2006

Contact allergy is not uncommon among dental professionals and patients. Besides sensitizers also present in the standard series, the most common allergens in this group are the (meth)acrylate monomers and elemental mercury. Amalgam has been almost completely replaced by (meth)acrylate-containing systems as the main dental restorative material in many countries.

Contact allergy to (meth)acrylates among dental professionals has been well-studied (1–6) and there are numerous epidemiologic studies available in the medical literature. In contrast, published information on contact allergy to (meth)acrylates among dental patients has mainly been case reports (7–9).

In Malmö University Hospital, 2 separate series have been used since 1997 to test dental patients and dental personnel. The (meth)acrylate allergens in both series are identical. A dental screening series from the beginning of the 1980s (10) was originally used for both stomatitis patients and those handling dental products, but since Novem-

ber 1997 the addition of a dental series for dental personnel was started. In this study, we report our data after 10 years of patch testing to (meth)acrylates in dental patients and dental personnel. We also aim to study the patterns of simultaneous positive patch test results with a view to selecting possible screening allergens, which may be incorporated into an abbreviated (meth)acrylate screening series for dental (meth)acrylate contact allergy.

Materials and methods

Patients

This is a 10-year retrospective study of all patients patch tested to the dental patient series and dental personnel series in the Department of Occupational and Environmental Dermatology, Malmö University Hospital, Sweden from 1 January 1995 to 31 December 2004. 1632 patients (1209 females and 423 males) had been tested: 1322 dental patients to the dental patient series (977 females and 345

males), 81 dental personnel to the dental patient series (56 females and 25 males), and 229 dental personnel to the dental personnel series (176 females and 53 males).

Patch testing

The allergens were applied onto small Finn Chambers[®] (Epitest Ltd Oy, Tuusula, Finland) on Scanpor[®] (Norgesplaster A/S, Vennessla, Norway). The tests were applied to the upper part of the back and left for 48 h. Tests were read on day 3 (D3) or D4 and D7 by a dermatologist and the reactions were scored according to ICDRG criteria.

Supplier of allergens

Chemotechnique Diagnostics, (Vellinge, Sweden) supplied the sensitizers for both series. The (meth)acrylates of the 2 series are identical and listed in Table 1 with concentrations and vehicle used.

Results

Overall

Of all 1632 patients tested, 48 (37 females and 11 males) had positive results to one or more (meth)acrylates. Positive patch tests to (meth)acrylate allergens were seen in 2.3% (30/1322) of the dental patients and 5.8% (18/310) of the dental personnel.

The most common allergen for both groups was 2-hydroxyethyl methacrylate (2-HEMA), followed by ethyleneglycol dimethacrylate (EGDMA) and

triethyleneglycol dimethacrylate (TREGDMA). The overall and individual series positive patch test frequencies are shown in Table 1. The results of the 2 different series have also been analyzed separately.

Overall simultaneous reaction patterns are shown in Table 2. 47 out of 48 (98%) had positive patch tests to 2-HEMA. Of these 47, 30 (63%) had simultaneous positive reactions to EGDMA. 30 patients had a positive reaction to EGDMA, and thus none without a simultaneous positive reaction to 2-HEMA. One (meth)acrylate positive individual was not positive to 2-HEMA but reacted to 2,2-bis[4-(2-hydroxy-3-methacryloxypropoxy)-phenyl]propane (bis-GMA). 12/13 (92%) subjects who had positive reactions to TREGDMA had simultaneous positive reactions to both 2-HEMA and EGDMA.

Overall, a short series with 2-HEMA and bis-GMA would have provided 100% coverage of all our dental (meth)acrylate-positive subjects independent of being dental patients or dental personnel.

Dental patients

The most common allergens were also 2-HEMA, EGDMA and TREGDMA (Table 1).

29 out of 30 subjects with positive patch tests to the (meth)acrylates in the dental patient series had positive reactions to 2-HEMA. The only one who was not, only reacted to bis-GMA. Simultaneous reaction patterns for dental patients are shown in Table 3.

Of those 29 who had reacted to 2-HEMA, 15 (52%) had simultaneous positive reactions to EGDMA.

All 6 dental patients who had positive reactions to TREGDMA had simultaneous positive reactions to 2-HEMA as well as EGDMA.

The minimum required screening allergens to detect all our dental patients with (meth)acrylate allergy would be 2-HEMA and bis-GMA.

If only one reading had been made (on D3 and not also on D7), we would have missed 7/29 (24%) 2-HEMA-positive and 3/15 (20%) EGDMA-positive dental patients. 2 of our 2-HEMA-positive dental patients had only developed positive patch tests on a third reading on D10, after they had been found to have negative or questionable readings on D3 and D7, thus increasing the figure to 9/29 (31%) not detected.

Dental personnel

The most common allergens were 2-HEMA, EGDMA, methyl methacrylate (MMA), and TREGDMA (Table 1). All 18 subjects had positive

Table 1. Positive patch test results in numbers and percentages in 30 dental patients and 18 dental personnel in Malmö from 1 January 1995 to 31 December 2004 when tested to various methacrylates

Test substance	Overall	Patients	Personnel
2-Hydroxyethyl methacrylate 2% pet	47 (97.9)	29 (96.7)	18 (100.0)
Ethyleneglycol dimethacrylate 2% pet	30 (62.5)	15 (50.0)	15 (83.3)
Triethyleneglycol dimethacrylate 2% pet	13 (27.0)	6 (20.0)	7 (38.8)
Methyl methacrylate 2% pet	11 (22.9)	4 (13.3)	7 (38.8)
Butanediol dimethacrylate 2% pet	9 (18.8)	4 (13.3)	5 (27.8)
Tetrahydrofurfuryl methacrylate 2% pet	6 (12.5)	3 (10.0)	3 (16.7)
bis-GMA 2% pet	4 (8.3)	2 (6.7)	2 (11.1)
Dimethylaminoethyl methacrylate 0.2% pet	4 (8.3)	2 (6.7)	2 (11.1)
Hexanediol diacrylate 0.1% pet	4 (8.3)	3 (10)	1 (5.6)
bis-MA 2% pet	1 (2.1)	0 (0)	1 (5.6)
Urethane dimethacrylate 2% pet	1 (2.1)	0 (0)	1 (5.6)

Table 2. Simultaneous reactions to (meth)acrylates in the dental patient series and dental personnel series in Malmö from 1 January 1995 to 31 December 2004 in numbers and percentages

	Methyl methacrylate*	Triethyleneglycol dimethacrylate*	Urethane dimethacrylate*	Ethyleneglycol dimethacrylate*	bis-GMA* dimethacrylate*	Butanediol dimethacrylate*	bis-MA* dimethacrylate*	2-Hydroxyethyl methacrylate*	Dimethylaminoethyl methacrylate 0.2% pet.	Hexanediol diacrylate 0.1% pet.	Tetrahydrofurfuryl methacrylate*
Methyl methacrylate*	11 (22.9)	9 (18.8)	1 (2.1)	10 (20.8)	2 (4.2)	6 (12.5)	0 (0)	11 (22.9)	4 (8.3)	3 (6.3)	5 (10.4)
Triethyleneglycol dimethacrylate*	9 (18.8)	13 (27.0)	1 (2.1)	12 (25.0)	2 (4.2)	7 (14.6)	0 (0)	13 (27.0)	4 (8.3)	3 (6.3)	6 (12.5)
Urethane dimethacrylate*	1 (2.1)	1 (2.1)	1 (2.1)	1 (2.1)	1 (2.1)	1 (2.1)	0 (0)	1 (2.1)	1 (2.1)	1 (2.1)	1 (2.1)
Ethyleneglycol dimethacrylate*	10 (20.8)	12 (25.0)	1 (2.1)	30 (62.5)	2 (4.2)	9 (18.8)	1 (2.1)	30 (62.5)	4 (8.3)	4 (8.3)	6 (12.5)
bis-GMA* dimethacrylate*	2 (4.2)	2 (4.2)	1 (2.1)	2 (4.2)	4 (8.3)	2 (4.2)	0 (0)	3 (6.3)	2 (4.2)	1 (2.1)	2 (4.2)
Butanediol dimethacrylate*	6 (12.5)	7 (14.6)	1 (2.1)	9 (18.8)	2 (4.2)	9 (18.8)	0 (0)	9 (18.8)	4 (8.3)	3 (6.3)	5 (10.4)
bis-MA* dimethacrylate*	0 (0)	0 (0)	0 (0)	1 (2.1)	0 (0)	0 (0)	1 (2.1)	1 (2.1)	0 (0)	0 (0)	0 (0)
2-Hydroxyethyl methacrylate*	11 (22.9)	13 (27.0)	1 (2.1)	30 (62.5)	3 (6.3)	9 (18.8)	1 (2.1)	47 (97.9)	4 (8.3)	4 (8.3)	6 (12.5)
Dimethylaminoethyl methacrylate	4 (8.3)	4 (8.3)	1 (2.1)	4 (8.3)	2 (4.2)	4 (8.3)	0 (0)	4 (8.3)	4 (8.3)	2 (4.2)	4 (8.3)
0.2% pet											
Hexanediol diacrylate	3 (6.3)	3 (6.3)	1 (2.1)	4 (8.3)	1 (2.1)	3 (6.3)	0 (0)	4 (8.3)	2 (4.2)	4 (8.3)	2 (4.2)
0.1% pet											
Tetrahydrofurfuryl methacrylate*	5 (10.4)	6 (12.5)	1 (2.1)	6 (12.5)	2 (4.2)	5 (10.4)	0 (0)	6 (12.5)	4 (8.3)	2 (4.2)	6 (12.5)

*Patch test concentration 2.0% w/w in petrolatum.

Table 3. Simultaneous reactions to (meth)acrylates in numbers and percentages in 30 dental patients patch tested to the dental patient series in Malmö from 1 January 1995 to 31 December 2004

	Methyl methacrylate*	Triethyleneglycol dimethacrylate*	Urethane dimethacrylate*	Ethyleneglycol dimethacrylate*	bis-GMA* bis-methacrylate*	Butanediol dimethacrylate*	bis-MA* bis-methacrylate*	2-Hydroxyethyl methacrylate*	Dimethylaminoethyl methacrylate 0.2% pet.	Hexanediol diacrylate 0.1% pet.	Tetrahydrofurfuryl methacrylate*
Methyl methacrylate*	4 (13.3)	4 (13.3)	0 (0)	4 (13.3)	0 (0)	2 (6.7)	0 (0)	4 (13.3)	2 (6.7)	2 (6.7)	2 (6.7)
Triethyleneglycol dimethacrylate*	4 (13.3)	6 (20)	0 (0)	6 (20)	0 (0)	2 (6.7)	0 (0)	6 (20)	2 (6.7)	2 (6.7)	3 (10)
Urethane dimethacrylate*	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Ethyleneglycol dimethacrylate*	4 (13.3)	6 (20)	0 (0)	15 (50)	0 (0)	4 (13.3)	0 (0)	15 (50)	2 (6.7)	3 (10)	3 (10)
bis-GMA*	0 (0)	0 (0)	0 (0)	0 (0)	2 (6.7)	0 (0)	0 (0)	1 (3.3)	0 (0)	0 (0)	0 (0)
Butanediol dimethacrylate*	2 (6.7)	2 (6.7)	0 (0)	4 (13.3)	0 (0)	4 (13.3)	0 (0)	4 (13.3)	2 (6.7)	2 (6.7)	2 (6.7)
bis-MA*	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
2-Hydroxyethyl methacrylate*	4 (13.3)	6 (20)	0 (0)	15 (50)	1 (3.3)	4 (13.3)	0 (0)	29 (96.7)	2 (6.7)	3 (10)	3 (10)
Dimethylaminoethyl methacrylate	2 (6.7)	2 (6.7)	0 (0)	2 (6.7)	0 (0)	2 (6.7)	0 (0)	2 (6.7)	2 (6.7)	1 (3.3)	2 (6.7)
0.2% pet											
Hexanediol diacrylate	2 (6.7)	2 (6.7)	0 (0)	3 (10)	0 (0)	2 (6.7)	0 (0)	3 (10)	1 (3.3)	3 (10)	1 (3.3)
0.1% pet											
Tetrahydrofurfuryl methacrylate*	2 (6.7)	3 (10)	0 (0)	3 (10)	0 (0)	2 (6.7)	0 (0)	3 (10)	2 (6.7)	1 (3.3)	3 (10)

*Patch test concentration 2.0% w/w in petrolatum.

reactions to 2-HEMA. Simultaneous reaction patterns for dental personnel are shown in Table 4.

Of the 18 who had reacted to 2-HEMA, 15 (83%) had simultaneous positive reactions to EGDMA. In all, 15 had a positive reaction to EGDMA. All 7 dental personnel who had positive reactions to MMA had simultaneous positive reactions to 2-HEMA while 6 had simultaneous positive reactions to EGDMA.

The only required screening allergen to detect all our dental personnel with (meth)acrylate allergy would be 2-HEMA.

If only one reading had been made (on D3 and not also on D7), we would have missed 3/18 (17%) 2-HEMA-positive and 1/15 (7%) EGDMA-positive dental personnel.

Discussion

Most studies on (meth)acrylate allergy in the dental setting have been performed on populations consisting of only dental personnel. In previous Swedish studies of dental personnel with reported skin symptoms, contact allergy to (meth)acrylates had been verified by patch testing in 5%–10% (3, 6). The most common allergens in all the various studies were 2-HEMA and EGDMA, with MMA and TREGDMA in some of the studies (Table 5). In one of the previous studies, 2-HEMA had been suggested as the main candidate for a screening allergen to detect sensitization to (meth)acrylates among dental professionals (5). In our study we also found this and thus strongly support 2-HEMA to be the screening allergen. In fact, there have been a few studies in the literature supporting 2-HEMA as a screening marker for acrylate allergy among dental professionals (3, 5) while other studies have not found this to be so (1, 2, 4). More studies are needed to determine whether the same applies to dental patients and dental personnel in other populations.

There has been no systematic study on (meth)acrylate allergy solely among the dental patient population. Most published data is from case reports or studies of wider populations, where dental patients comprise only a minority of the subjects studied (11). In this study, we have found that 2-HEMA and bis-GMA would screen for all our (meth)acrylate-allergic dental patients. However, only 2 of our dental patients had a positive patch test to bis-GMA, one who had a simultaneous sensitivity to 2-HEMA and another with no other positive (meth)acrylate patch test result. Therefore, omitting bis-GMA would have resulted in us missing only 1 out of the 30 (meth)acrylate-allergic dental patients.

On the whole, screening for (meth)acrylate contact allergy with 2-HEMA alone would have allowed us to pick up 97% (29/30) of our (meth)acrylate-allergic dental patients and 100% (18/18) of our (meth)acrylate-allergic dental personnel. The addition of the second screening allergen, which would be bis-GMA in dental patients, would increase the pick-up rate to 100%.

The importance of more than one patch test reading is also demonstrated in our study. If only one reading had been made, we would have missed 24% 2-HEMA-positive and 20% EGDMA-positive dental patients, as well as 17% 2-HEMA-positive and 7% EGDMA-positive dental personnel. In fact, 2 of our 2-HEMA-positive dental patients had only developed positive patch tests on a third reading on D10, after they had been found to have negative or questionable readings on D3 and D7, thus increasing the figure to 31% not detected. A recent study from Sweden showed that patch test reactions to 2-HEMA may show up as late-appearing test reactions (beyond day 7) without having to be patch test sensitization (12).

It is interesting to note that all of our EGDMA-positive patients had simultaneous sensitivity to 2-HEMA. This could be due to cross-reactivity between the 2 substances. However, the frequency of simultaneous contact allergy to 2-HEMA and EGDMA differs between the 2 study groups. Of the 18 2-HEMA positive personnel, 15 (83%) reacted to EGDMA in contrast to 15/29 (52%) dental patients, a statistically significant difference (Fisher's exact 2-sided test, $P = 0.03$). The reason for this discrepancy could be the dental personnel having stronger patch test reactions to 2-HEMA than the dental patients. Indeed, there is a statistically significant difference between the strength of the contact allergic reactions to 2-HEMA in the dental personnel compared to the dental patients (Mann–Whitney, $P = 0.01$).

Furthermore, in every subject with simultaneous positive patch tests to 2-HEMA and EGDMA in both the dental patients and dental personnel subsets, the strength of the positive reaction to 2-HEMA was either greater than or equal to the strength of the positive reaction to EGDMA. In general, positive reactions to HEMA tend to be stronger than those to EGDMA (Table 6). The significance of these findings is still undetermined.

There is a theory that the dose of the sensitizer at induction is significant for the degree of hypersensitivity. Whether this could explain the statistically significant difference in the strength of the allergic reactions between the dental patients and the dental personnel with respect to 2-HEMA

Table 4. Simultaneous reactions to (meth)acrylates in numbers and percentages in 18 dental personnel patch tested to the dental patient series or the dental personnel series in Malmö from 1 January 1995 to 31 December 2004

	Methyl methacrylate*	Triethyleneglycol dimethacrylate*	Urethane dimethacrylate*	Ethyleneglycol dimethacrylate*	bis-GMA*	Butanediol dimethacrylate*	bis-MA*	2-Hydroxyethyl methacrylate*	Dimethylaminoethyl methacrylate 0.2% pet.	Hexanediol diacrylate 0.1% pet.	Tetrahydrofurfuryl methacrylate*
Methyl methacrylate*	7 (38.8)	5 (27.8)	1 (5.6)	6 (33.3)	2 (11.1)	4 (22.2)	0 (0)	7 (38.8)	2 (11.1)	1 (5.6)	3 (16.7)
Triethyleneglycol dimethacrylate*	5 (27.8)	7 (38.8)	1 (5.6)	6 (33.3)	2 (11.1)	5 (27.8)	0 (0)	7 (38.8)	2 (11.1)	1 (5.6)	3 (16.7)
Urethane dimethacrylate*	1 (5.6)	1 (5.6)	1 (5.6)	1 (5.6)	1 (5.6)	1 (5.6)	0 (0)	1 (5.6)	1 (5.6)	1 (5.6)	1 (5.6)
Ethyleneglycol dimethacrylate*	6 (33.3)	6 (33.3)	1 (5.6)	15 (83.3)	2 (11.1)	5 (27.8)	1 (5.6)	15 (83.3)	2 (11.1)	1 (5.6)	3 (16.7)
bis-GMA*	2 (11.1)	2 (11.1)	1 (5.6)	2 (11.1)	2 (11.1)	2 (11.1)	0 (0)	2 (11.1)	2 (11.1)	1 (5.6)	2 (11.1)
Butanediol dimethacrylate*	4 (22.2)	5 (27.8)	1 (5.6)	5 (27.8)	2 (11.1)	5 (27.8)	0 (0)	5 (27.8)	2 (11.1)	1 (5.6)	3 (16.7)
bis-MA*	0 (0)	0 (0)	0 (0)	1 (5.6)	0 (0)	0 (0)	1 (5.6)	1 (5.6)	0 (0)	0 (0)	0 (0)
2-Hydroxyethyl methacrylate*	7 (38.8)	7 (38.8)	1 (5.6)	15 (83.3)	2 (11.1)	5 (27.8)	1 (5.6)	18 (100)	2 (11.1)	1 (5.6)	3 (16.7)
Dimethylaminoethyl methacrylate	2 (11.1)	2 (11.1)	1 (5.6)	2 (11.1)	2 (11.1)	2 (11.1)	0 (0)	2 (11.1)	2 (11.1)	1 (5.6)	2 (11.1)
0.2% pet											
Hexanediol diacrylate	1 (5.6)	1 (5.6)	1 (5.6)	1 (5.6)	1 (5.6)	1 (5.6)	0 (0)	1 (5.6)	1 (5.6)	1 (5.6)	1 (5.6)
0.1% pet											
Tetrahydrofurfuryl methacrylate*	3 (16.7)	3 (16.7)	1 (5.6)	3 (16.7)	2 (11.1)	3 (16.7)	0 (0)	3 (16.7)	2 (11.1)	1 (5.6)	3 (16.7)

*Patch test concentration 2.0% w/w in petrolatum.

Table 5. Studies on dental occupational (meth)acrylate contact allergy

Author(s)	Year	No.	Population	Commonest allergens
Rustemeyer T et al.	1996	1132	Dental technicians	MMA, 2-HEMA, EGDMA
Kiec-Swierzczynska M	1996	1619	Occupational cases	EGDMA, MMA, 2-HEMA, TREGDMA
Wallenhammar L et al.	2000	191	Dentists	2-HEMA, EGDMA
Geukens S et al.	2001	13,833	All patients suspected of contact dermatitis	EGDMA, 2-HEMA, TREGDMA
Wrangsjö K et al.	2001	174	Dental personnel	2-HEMA, EGDMA, MMA

(Table 6) is difficult to say. The dental personnel are exposed to 2-HEMA more frequently when working with bonding products than the dental patients. The dental personnel come into contact with it on the skin while the dental patients are exposed on the mucosa, where the density of the Langerhan's cell population is lower than in the skin. We also know from an earlier study that in patients with a weak contact allergy to 2-HEMA, the allergic reaction appears later than in those whose patch test reactions are stronger (12). However, in the present study, there is no statistically significant difference between patch test results for 2-HEMA in dental personnel on D3/4 vs D7 ($P = 0.72$, Fisher's exact 2-sided test).

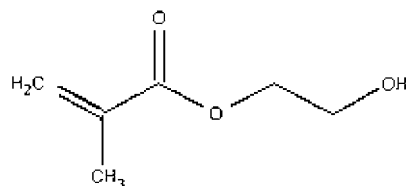
All patients hypersensitive to MMA, independent of being dental personnel or dental patients, tested positive to 2-HEMA. Of the 2-HEMA positive patients (7/18) 39% and (4/29) 14% had simultaneous reactions to MMA depending on whether they were dental personnel or dental patients. The difference in frequencies between the 2 groups could be due to different levels of exposure to MMA or to cross-reactivity between MMA and 2-HEMA. If cross-reactivity were the mechanism involved, the frequency of simultaneous reactions ought to have been higher among the dental patients, since 29 of them had reacted to 2-HEMA. Or else, it could have been that the strength of the contact allergy to 2-HEMA in the dental patients with simultaneous MMA and 2-HEMA positivity was much lower, which, however, was not the case. Therefore, different levels of exposure to MMA is the more likely explanation for this difference in frequencies.

The chemical structures of 2-HEMA and EGDMA are shown in Figure 1. 2-HEMA and

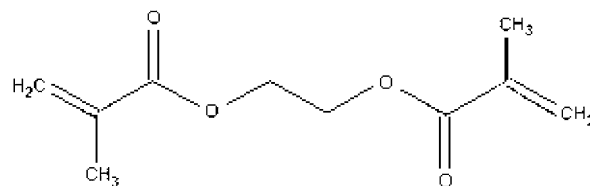
EGDMA are manufactured by esterifying ethylene glycol with methacrylic acid. Thus, 2-HEMA is the mono-ester of ethylene glycol and EGDMA the di-ester. 2-HEMA can be present as an impurity in EGDMA and EGDMA can be present as an impurity in 2-HEMA. Furthermore, EGDMA can be metabolized to 2-HEMA in the skin and body by enzymatic hydrolysis in cells and plasma, but 2-HEMA cannot be metabolized to EGDMA.

The issue of simultaneous sensitivity to multiple (meth)acrylate allergens has long been discussed (13, 14). Whether this has been due to cross-reactivity between different (meth)acrylate monomers, concomitant sensitization, or impurities (common or cross-reacting) within preparations used for testing and at workplaces, makes elucidation of the pattern of contact sensitivities to these substances difficult. In order to elucidate the cross-reaction pattern of (meth)acrylate allergens in humans, we would require individuals exposed to pure substances as well as commercial patch test substances that are pure. However, the former is never the case. Therefore, cross-reaction patterns can only be established in animal studies, with substances of high purity used for induction and elicitation (15, 16).

(Meth)acrylates are potent sensitizers, and as such, patch test sensitization may occur. Active sensitization to patch test allergens had also been



2-hydroxyethyl methacrylate (2-HEMA)



ethyleneglycol dimethacrylate (EGDMA)

Table 6. Highest individual patch test reactivity in dental patients and dental personnel for 2-HEMA and EGDMA when read on D3/D4 or D7

Strongest reaction	Dental patients		Dental personnel	
	2-HEMA (n = 29)	EGDMA (n = 15)	2-HEMA (n = 18)	EGDMA (n = 15)
+++	7 (24%)	3 (20%)	11 (61%)	7 (47%)
++	20 (70%)	10 (67%)	7 (39%)	8 (53%)
+	2 (7%)	2 (13%)	0	0

Fig. 1. The chemical structures of 2-hydroxyethyl methacrylate (2-HEMA) and ethyleneglycol dimethacrylate (EGDMA).

a problem in the earlier studies (15). This has been diminished with the use of lower concentrations of allergens for patch testing (17).

In summary, this study points out the importance of 2-HEMA as a screening allergen to detect contact allergy to (meth)acrylates used in the dental profession, both to pick up the dental patients and the dental personnel. In view of the results, a shortened dental series containing 2-HEMA and bis-GMA as the only (meth)acrylate allergens could be used as a screening series. If a patient reacts to 2-HEMA and/or bis-GMA, the testing could be supplemented with a broader dental series containing the various (meth)acrylates currently present in the commercial dental series.

The overall frequency of (meth)acrylate contact allergy in this study is 2.9% in these targeted groups. In our clinics in Malmö, Sweden, and Singapore, we have included 5 (meth)acrylate allergens in our standard series to see whether patients with such contact allergy are missed without targeted testing.

Finally, the importance of late readings must be stressed, as 1/4 of the dental patients with 2-HEMA-allergy and 20% with EGDMA-allergy would have otherwise been missed.

Acknowledgements

We thank Professor emeritus Bert Björkner, Department of Occupational and Environmental Dermatology, Malmö, Sweden, who has, since the early 1980s, been a pioneer both locally and nationally in the formation of a dental screening series and has had a great impact on the composition of the dental screening series.

References

1. Rustemeyer T, Frosch P J. Occupational skin diseases in dental laboratory technicians. (I). Clinical picture and causative factors. *Contact Dermatitis* 1996; 34: 125–133.
2. Kiec-Swierczynska M K. Occupational allergic contact dermatitis due to acrylates in Lodz. *Contact Dermatitis* 1996; 34: 419–422.
3. Wallenhammar L M, Ortengren U, Andreasson H, Barregard L, Björkner B, Karlsson S, Wrangsjö K, Meding B. Contact allergy and hand eczema in Swedish dentists. *Contact Dermatitis* 2000; 43: 192–199.
4. Geukens S, Goossens A. Occupational contact allergy to (meth)acrylates. *Contact Dermatitis* 2001; 44: 153–159.
5. Wrangsjö K, Swartling C, Meding B. Occupational dermatitis in dental personnel: contact dermatitis with special reference to (meth)acrylates in 174 patients. *Contact Dermatitis* 2001; 45: 158–163.
6. Lindberg M, Silverdahl M. The use of protective gloves and the prevalence of hand eczema, skin complaints and allergy to natural rubber latex among dental personnel in the county of Uppsala, Sweden. *Contact Dermatitis* 2000; 43: 4–8.
7. Koutis D, Freeman S. Allergic contact stomatitis caused by acrylic monomer in a denture. *Australas J Dermatol.* 2001; 42: 203–206.
8. Kanerva L, Alanko K, Estlander T. Allergic contact gingivostomatitis from a temporary crown made of methacrylates and epoxy diacrylates. *Allergy* 1999; 54: 1316–1321.
9. Carmichael A J, Gibson J J, Walls A W. Allergic contact dermatitis to bisphenol-A-glycidyl dimethacrylate (BIS-GMA) dental resin associated with sensitivity to epoxy resin. *Br Dent J* 1997; 183: 297–298.
10. Axell T, Björkner B, Fregert S, Niklasson B. Standard patch test series for screening of contact allergy to dental materials. *Contact Dermatitis* 1983; 9: 82–84.
11. Kanerva L, Rantanen T, Aalto-Korte K et al. A multicenter study of patch test reactions with dental screening series. *Am J Contact Dermat* 2001; 12: 83–87.
12. Isaksson M, Lindberg M, Sundberg K, Hallander A, Bruze M. The development and course of patch-test reactions to 2-hydroxyethyl methacrylate and ethyleneglycol dimethacrylate. *Contact Dermatitis* 2005; 53: 292–297.
13. Koppula S V, Fellman J H, Storrs F. Screening allergens for acrylate dermatitis associated with artificial nails. *Am J Contact Dermatitis* 1995; 6: 78–85.
14. Kanerva L. Cross-reactions of multifunctional methacrylates and acrylates. *Acta Odontol Scand* 2001; 59: 320–329.
15. Kanerva L, Estlander T, Jolanki R. Sensitization to patch test acrylates. *Contact Dermatitis* 1988; 18: 10–15.
16. Björkner B. Allergenicity of trimethylol propane triacrylate in ultraviolet curing inks in the guinea pig. *Acta Derm Venereol* 1980; 60: 528–531.
17. Kanerva L, Estlander T, Jolanki R. Occupational skin allergy in the dental profession. *Dermatol Clin* 1994; 12: 517–532.

Address:

Anthony Teik Jin Goon
National Skin Centre
1 Mandalay Road
Singapore 308205
e-mail: anthonygoon@nsc.gov.sg