

The outcome of dimethylglyoxime testing in a sample of cell phones in Denmark

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Background: Nickel dermatitis may be caused by frequent and prolonged use of cell phones. Because little is known about the frequency of nickel release from cell phones, it is difficult to estimate the risk of nickel sensitization and dermatitis among their users.

Objective: Inspired by a recent case of nickel dermatitis from prolonged cell phone use, the frequency of dimethylglyoxime (DMG)-positive cell phones on the Danish market was investigated.

Methods: Five major cell phone companies were contacted. Two were visited, and the DMG test was performed on a sample of their products.

Results: 5 of 15 (33.3%) phones from company A and 3 of 26 (11.5%) phones from company B showed at least 1 positive reaction. 3 phones had more than 1 positive DMG spots.

Conclusions: This study documents that excessive nickel release (i.e. a positive DMG test) is relatively frequent in a sample of cell phones from the Danish market. Prolonged use of cell phones may in some cases fulfil the criteria for items included in the European Union Nickel Directive. We believe that this new cause of nickel dermatitis should be carefully followed and that regulatory steps may be necessary.

Key words: cell phone; contact allergy; contact dermatitis; contact sensitization; dimethylglyoxime test; epidemic; metal; nickel. © Blackwell Munksgaard, 2008.

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Nickel is the most common cause of contact sensitization in the general population (1) as well as among dermatitis patients (2). During the second half of the 20th century, the nickel epidemic was mainly explained by consumer exposure to nickel-plated suspenders (3), blue jeans with metal buttons and zippers (4), and finally custom jewellery (5). As a result, the frequency of positive patch test to nickel increased in many countries; for example, in Malmö, Sweden, a 22% increase was observed among female patients between 1962 and 1997 (6). In 1990 and 1994, Nickel Directives were passed in Denmark and the European Union (EU) to diminish nickel release from consumer products intended to be in prolonged skin contact (7, 8). So far, the effect of these directives has been suggested in clinical material (2, 9) as well as population-based studies (10, 11).

Reports have described nickel (and chromium) dermatitis caused by frequent and prolonged use

of cell phones (12–15). At present, cell phones are not included in the EU Nickel Directive, although they are often in prolonged skin contact. We recently diagnosed one patient with nickel dermatitis caused by frequent and long-term use of a cell phone (Fig. 1). We therefore decided to investigate the frequency of dimethylglyoxime (DMG)-positive cell phones on the Danish market using a standard DMG test (16). DMG testing of consumer products as well as work tools has previously been carried out in Sweden (17–19). This paper presents the main findings of a Danish survey and discusses its implications.

Materials and Methods

The five largest cell phone companies on the Danish market were contacted and informed that we wished to determine the frequency of cell phones that demonstrated a positive DMG test. Two



Fig. 1. Vesicular eczema from repeated long-term use of a dimethylglyoxime test-positive cell phone.

companies accepted the invitation (covering more than 50% of the market), two companies declined, whereas one company never responded to our repeated invitations. Personal visits to participating companies were performed.

DMG testing was supervised by a company representative in a company office. All cell phones had metallic exteriors and were selected by the company representative in advance. Examined cell phones represented all cell phones the companies had in stock at the time of testing. None of the companies had any production facilities in Denmark, and the cell phones were therefore a sub sample of available cell phones produced by the given company. No earphones were tested, although this could have showed important information about nickel exposure as they are often in long-term skin contact.

Two separate test solutions were prepared by a hospital pharmacy (from the Capital Region of Copenhagen) and consisted of 1% DMG in alcohol and 10% ammonium hydroxide in water (16, 20). All parts of the cell phones that potentially came into direct and prolonged skin contact were examined. The test was administered by placing 2 drops of each solution in succession on a white cotton-wool-tipped applicator that was rubbed for up to 20 seconds against the cell phone. A positive reaction was indicated by a pink or a red discolouration of the applicator, whereas a negative reaction was registered when no colour change was observed. Doubtful reactions were retested, and if the reaction remained doubtful, it was considered negative.

Case report

A 28-year-old woman was referred with nummular eczema on her left cheek that had lasted more than 1 year. The referring dermatologist had

already performed histological examination that showed dermatitis and patch testing that showed a positive reaction for nickel. The patient presented with an area of 3 × 3 cm with erythema, papules, and a few vesicles on her left cheek (Fig. 1). Her medical history showed antecedent contact dermatitis from custom jewellery (including white gold). In addition, she used her cell phone for occupational conversation purposes for more than 2 hr per day. DMG testing of her cell phone (Siemens) showed a strong positive reaction. The eczema responded rapidly to corticosteroids, and the patient was advised to change her phone.

Results

DMG test results

Tables 1 and 2 show the outcome of DMG testing among 41 phones produced by 2 international cell phone companies. Five of 15 (33.3%) phones from company A and 3 of 26 (11.5%) phones from company B showed at least 1 positive reaction. Three phones had more than one positive DMG spots. The location of all DMG-positive spots (cases and keys) made skin contact likely. No relation between the year of marketing and outcome of DMG testing was identified. No relation between the sale price of the cell phones and the outcome of DMG testing was identified.

Information from company representatives

Cell phones are generally for sale on the Danish market for approximately 1–2 years. Demo phones in stores are most often made of different materials than the ones that are actually sold.

Table 1. Outcome of dimethylglyoxime (DMG) testing among 15 cell phones from company 1 marketed between 2004 and 2006 in Denmark

Cell phone	Model	Year of first arrival on market	No. of spots	
			Tested	DMG positive
1	1	2004	1	0
2	2	2004	3	0
3	3	2004	3	0
4	4	2004	3	0
5	5	2004	3	1
6	6	2005	3	1
7	6	2005	3	2
8	6	2005	3	1
9	6	2005	3	0
10	6	2005	3	0
11	7	2006	3	1
12	8	2006	3	0
13	9	2006	3	0
14	10	2006	3	0
15	11	2006	3	0
Total			43	6

Table 2. Outcome of dimethylglyoxime (DMG) testing among 26 cell phones from company B marketed between 2003 and 2007 in Denmark

Cell phone	Model	Year of first arrival on market	No. of spots	
			Tested	DMG positive
1	1	2003	1	0
2	2	2004	2	0
3	3	2004	2	0
4	4	2004	2	0
5	5	2004	4	0
6	6	2005	3	0
7	7	2005	3	0
8	8	2005	3	0
9	9	2005	4	0
10	10	2005	4	0
11	11	2005	5	0
12	12	2006	3	0
13	13	2006	3	0
14	14	2006	4	2
15	15	2006	3	0
16	16	2006	4	3
17	17	2006	3	0
18	18	2006	3	0
19	19	2006	5	0
20	20	2006	2	0
21	21	2006	3	0
22	22	2007	2	0
23	23	2007	2	1
24	24	2007	3	0
25	25	2007	3	0
26	26	2007	4	0
Total			80	6

Thus, demo phones may be of no use for nickel-sensitive patients using the DMG spot test prior to purchase (or for the aim of our investigation). Unpublished company surveys showed that Danish consumers use their cell phones for approximately 1.5 years before discarding it. Both companies had environmental departments that handle all health-related issues. They were aware that nickel dermatitis can be caused by long-term exposure to nickel but had not received any complaints of allergic reactions or dermatitis by Danish customers. One company defined long-term exposure as skin contact lasting more than 10 min. The background for this time limit was unknown to the representative but had been determined to limit nickel exposure among cell phone users. Both companies tried to avoid nickel in their products. One company recently decided to replace nickel with other metals such as titanium and aluminium in all future metallic cell phones. Parts and components were mostly produced by individual Asian suppliers not owned by the companies. Identical phones may therefore contain different parts and components depending on availability and prices at the time of production (e.g. a phone that was sold in more than 100 million copies worldwide was DMG positive in 2 of 5

cases when 5 identical phones were examined). In general, nickel was used in the electronic components inside the phones. According to company representatives, metal cases were often covered by chromium (with small pores) but nickel could also be integrated in the cases underneath the chromium layer.

Discussion

This study demonstrates positive DMG testing (indicating nickel release $>0.5 \mu\text{g}/\text{cm}^2$ per week) in 11–33% of 41 cell phones sold in Denmark between 2003 and 2007. We speculate that the outcome of the study is representative of the entire market and that possible DMG testing of phones from companies that did not participate in the study would have turned out similar. To support this assessment are case reports of cell phone-elicited nickel dermatitis caused by phones from companies that did not participate (13, 15). Furthermore, cell phones that were examined in this study were identical to phones sold in other European countries, and similar results would therefore be expected if studies had been performed elsewhere. In particular, one DMG-positive cell phone was sold in more than 100 million copies worldwide.

Positive outcomes of DMG testing were observed on all exterior parts of examined cell phones, i.e. case parts and keys. However, no specific parts were more often DMG positive than other parts. It is likely that nickel sensitization and dermatitis may occur from both frequent text messaging and long or repeated conversations. We have no knowledge about time required to sensitize and elicit contact dermatitis from the use of a cell phone. One company defined long-time skin exposure as more than 10 min, but the scientific basis behind this definition was unknown. Currently, there is no regulatory definition or public scientific evidence that has identified the minimum exposure time required to sensitize and elicit nickel dermatitis. The accumulation of reports describing nickel dermatitis from the use of cell phones (12, 13, 15) suggests that the EU Nickel Directive should also cover nickel-releasing items that are in short-term skin contact (i.e. few hours). However, an exact definition should be based on future scientific research.

Cell phone production (at least at participating companies in this study) is performed with components from changing suppliers depending on availability and prices at the time of manufacturing. Thus, it is not possible to generalize results from DMG testing and assume that other identical phones display the same test result. Cell phone

DMG testing should therefore, always be performed on the actual phone used by the patient if cell phone-elicited nickel dermatitis is suspected or if that person is already nickel sensitized.

The DMG spot test analysis is ultimate in simplicity, making it practical for screening purposes (20). The sensitivity (and specificity) of the DMG test has previously been questioned (21–25). In case of suspected false-negative DMG reaction, the surface may be pretreated with artificial sweat to dissolve the protective layer (24). However, it is generally acknowledged that the DMG test gives a reliable estimate of nickel release.

Reports of cell phone-elicited nickel dermatitis have been described only in facial locations (12, 13, 15). Whether prolonged use of cell phones, for example, text messaging or hand support during conversation, may play a role in the development of hand eczema has not been investigated. In Denmark, several cell phone operators offer unlimited text-messaging packages. Repeated non-occlusive skin exposure to low nickel concentrations is clinically relevant among patients with nickel allergy and hand eczema (26). Thus, the DMG status of cell phones may be of relevance in some patients with intractable hand eczema and a history of frequent cell phone use. The benefit of DMG testing and possible avoidance of the suspected cell phone is supported by previous scientific research demonstrating that patients with nickel allergy who eliminate long-lasting contact with metals have a better prognosis (irrespective of occupation) (27).

The EU Nickel Directive prohibits products that are intended to come into direct and prolonged skin contact (e.g. jewellery, zippers, and buttons but not yet cell phones) and at the same time releases more than 0.5 μg nickel/cm² per week (7, 8). An effect from these regulations has so far been demonstrated in both Denmark and Germany in terms of decreasing prevalences of nickel allergy in clinical material and the general population (2, 9, 11, 28). However, results from patch test clinics around Europe also show that nickel is still the most common contact allergen among all age groups (2, 29). Changes in consumer habits (e.g. increased use of cell phones) as well as changes in composition of consumer products (e.g. replacement of plastic cases with metallic cases in modern cell phones) may contribute to continuous high-prevalence estimates of nickel sensitization (12, 13, 15).

We identified nickel dermatitis on the left cheek of a 28-year-old patient who was exposed to nickel from prolonged occupational use of her cell phone (~2 hr of conversation per day) (Fig. 1). Her history was comparable to those observed in other

reports (12, 13, 15). Hence, we estimate that prolonged use of cell phones in some cases fulfil the criteria for items included in the EU Nickel Directive. Further knowledge about minimum exposure time required to elicit nickel dermatitis is warranted for safety assessment of consumer products. Finally, this new cause of nickel dermatitis should be carefully followed and regulatory steps considered.

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