Mobile Phone Dermatitis in Children and Adults: A Review of the Literature

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Background: Mobile phones have been reported to cause allergic contact dermatitis (ACD).

Methods: A comprehensive online literature review was conducted through the National Library of Medicine (Pubmed MEDLINE) using appropriate medical subject headings and keywords.

Results: Thirty-seven cases of mobile phone-related ACD were found. Six studies evaluating allergen release from mobile phones were found.

Conclusions: Case reports of mobile phone-associated ACD have risen rapidly in number since 2000. Case reports highlight mobile phone ACD in both pediatric and adult populations in many countries. Metal allergens, notably nickel and chromium, were frequently implicated in mobile phone associated ACD. Nickel release from mobile phones appears to be common and has been reported in both cheap and expensive mobile phones, including phones covered under the EU Nickel Directive.

Introduction

ALLERGIC CONTACT DERMATITIS (ACD), a T-cell mediated hypersensitivity reaction, is common in adults and children worldwide. For example, this condition is often observed following cutaneous exposure to metallic items that release nickel in high concentrations. Importantly, patch test reactivity to nickel affects up to 17% of women and 3% of men from the general population.¹ In addition, nickel sensitization is common in children, with ACD prevalence estimates ranging from 17% to 33%.² Nickel may be released from a wide variety of commonplace items, such as jewelry, belt buckles, zippers, buttons, snaps, glasses, coins, and keys.^{3–7} Nickel release in amounts that are sufficient to elicit ACD in nickel-sensitized individuals may be easily evaluated in a quick, nondestructive manner using the nickel dimethylglyoxime spot test (DMG).⁸ More recently, items such as mobile phones, laptop computers, video game controllers, and other technology accessories have also provided sources of nickel sensitization and ACD.^{9,10}

Chromium and cobalt are also frequent culprits causing ACD. Positive patch test results in recent studies among dermatitis patients reached 2.3% and 6.2% respectively.¹¹ Chromium is found in cement, stainless steel, and leather items.¹² At present, no spot test has been used systematically to screen consumer goods for chromium release. While cobalt is frequently used in hard metal alloys and medical

implants, its use in consumer items such as jewelry, belt buckles, and work tools seems to be limited. This observation is based on the recently developed cobalt spot test that has been used in several market surveys.^{6,13}

An exponential rise in mobile phone usage has been observed in the last decades. A report in 2011 estimated that there are 85 mobile phone subscriptions per 100 people globally,¹⁴ a figure that is predicted to increase. Reports of ACD to the mobile phone have been reported since 2000, when Pazzaglia et al. reported two cases of nickel allergy elicited by mobile phone use.¹⁵ The goals of this review are (1) to present published cases of mobile phone dermatitis, (2) to identify and summarize those studies that have investigated nickel and cobalt release from mobile phones using screening spot tests, and (3) to provide the general dermatologist, immunologist, or pediatrician with a basic understanding of etiology, clinical presentation, and prevalence of mobile phone ACD.

Methods

A review of the literature was carried out using the National Library of Medicine (Pubmed MEDLINE). Medical subject headings (MeSH terms), utilized in various combinations, included: cellular phone, cell phone, mobile phone, contact sensitization, dermatitis, nickel, cobalt, chromium, metal, sensitization, and allergy. Studies and case reports on

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ACD and mobile phones were reviewed and included. All studies not mentioning mobile phones or ACD were excluded. Non-English studies were not excluded. As mobile phone dermatitis is a relatively new condition and our intent was to be as comprehensive as possible, both adult and pediatric cases and studies were included.

Results

Mobile phone dermatitis and nickel ACD

Here we provide an overview of clinical reports describing ACD from mobile phone use. The majority of studies and reports have been linked to nickel allergy. Pazzaglia¹⁵ reported two patients with persistent facial dermatitis who both patch tested positive to 5% nickel sulfate at days 2 and 3. Since this pioneer case study in 2000, we identified 35 additional cases of mobile phone and mobile phone accessory dermatitis reported within 20 publications (Table 1).^{2,16–34} Of these cases, 27 implicated nickel.^{2,16–25,27–32}

In 2003, a case report of eight patients with ACD from mobile phones was published, one of whom patch tested positive for nickel, and one with a doubtful reaction to nickel.¹⁷ Allergy to both nickel sulfate and potassium dichromate was diagnosed in one patient, while the other had a questionable patch test result to nickel, chromium, and indium.

Four years later in 2007, two more cases of nickel ACD from mobile phone use were reported. One presented as bilateral facial dermatitis¹⁸ and the other as pruritic, lichenified dermatitis of hands, forearms, and face.¹⁹ Both patients showed strong patch test reactivity to 5% nickel, and both mobile phones had positive DMG spot test reactions.

In 2008, Luo and Berkovitch reported another unusual localization of mobile phone dermatitis from nickel.²⁰ Their patient, an 18-year-old male, reported eczematous dermatitis of his lower abdomen, extremities, flanks, and face. Patch testing revealed allergy to nickel at 72 hours, but negative reactions to gold, cobalt, chromium, copper, and palladium. His mobile phone showed a positive DMG test in multiple areas. Two additional studies were published in 2008 detailing cases of nickel dermatitis presenting as facial dermatitis.^{21,22}

From 2009–2011, seven additional case reports of nickel-induced dermatitis were published, detailing reactions in 15 patients.^{2,23–25,27–29} Notably, of the 12 patients among this group for whom age was reported, eight (66.67%) were aged 18 years or younger. All patients had either a positive patch test to nickel, a positive DMG spot test of their mobile phone, or both. All patients' dermatitis resolved after discontinuing use of their mobile phones. Fourteen of the cases included facial dermatitis,^{2,23,24,27–29} and three cases included dermatitis on additional parts of the body, such as the wrists²⁴ or anteriolateral thighs.^{25,28} Rajpara and Feldman published an additional case report of facial mobile phone dermatitis in 2010, but it does not report results of either patch or DMG test.²⁶

In 2011 and 2012, the two most recent reports of mobile phone dermatitis from nickel were reported.^{31,32} Suarez et al. described a 14-year-old female presenting with pruritic, scaling papules between the breasts as well as on the lower abdomen.³¹ The cause of her abdominal dermatitis

was determined to be a nickel-containing belt buckle, but the cause of her breast dermatitis was determined to be her mobile phone. She habitually carried her mobile phone tucked into her bra and developed dermatitis in this area. Dannepond and Armingaud reported a similar case of dermatitis on the superior quadrants of the breasts of a 17-year-old female patient, also caused by a nickel-releasing mobile phone.³² These two cases represent a departure from the previous reports of mobile phone dermatitis, which all detail reactions on the face or anterior thighs.

The presented cases highlight the prevalence of mobile phone ACD due to nickel in both adults and children. Also, we highlight various presenting symptoms and characteristic distributions, namely face, especially preauricular and cheek, hands, thighs, and chest/breasts. Clinicians should have an increased suspicion of mobile phone contact dermatitis to patients with dermatitis in these distributions, especially in the case of patients with unusual mobile phone habits, occupational mobile phone use, or a new mobile phone.

Spot test assessment of nickel and cobalt release from mobile phones

In addition to case reports, publications have evaluated nickel and cobalt release from mobile phones. Here we provide a description of the published studies. A Danish study from 2008 showed that among 41 mobile phones produced by two international mobile phone companies, nickel was released from eight phones (19.5%) with DMG-positive spots on the cases, buttons, and keypads.²¹ Another study performed by the Danish Broadcasting Company in 2008 showed excessive nickel release from 13 of 50 (26%) tested mobile phones.³⁵ An American study, also published in 2008, performed similar DMG spot testing on 22 models of mobile phones and one Bluetooth headset from eight manufacturers, resulting in positive reactions from 10 phones (45.5%).²⁰ In 2011, after the addition of mobile phones to the EU nickel directive,³⁶ Jensen et al. tested a sample of 50 mobile phones from the Danish market for nickel release.³⁷ Using DMG spot tests, they found nickel release in nine phones (18%), hence indicating that the EU Nickel Directive was not followed sufficiently by many manufacturers. Most recently, Aquino et al. used spot tests to evaluate nickel and cobalt release from 72 devices that represented 16 unique mobile phone models. They found that 24 of the total 72 devices released nickel (33%), with 9 out of the 16 unique models having at least one positive result (56%).³⁸

Though fewer data exist on the release of cobalt from mobile phones, a recent study of cobalt release from mobile phones assessed by cobalt spot test was conducted in Denmark and 0 of 50 mobile phone models was found to release cobalt.³⁹ In contrast, Aquino et al. found that 10 of the total 72 devices released cobalt (14%) with 4 out of the 16 unique models having at least one positive result (25%).³⁸ Combined available data from spot testing can be found in Table 2.

In another study assessing nickel release by spot test in belts, it has been noted lower purchase price may be associated with increased likelihood of nickel release.⁶ It is worth mentioning that while no such data exist in the assessment of mobile phones, nickel release from expensive mobile phones is not to be overlooked. A recent publication

TABLE 1. TWENTY-ONE PUBLICATIONS REPORTING MOBILE PHONE DERMATITIS

<i>Number</i>	<i>Title</i>	<i># Cases</i>	<i>Age (gender)</i>	<i>Distribution</i>	<i>Cell Phone Brand</i>	<i>Patch Test Results</i>	<i>Phone Testing</i>	<i>Authors</i>	<i>Country</i>	<i>Journal</i>	<i>Citation</i>
1	Contact dermatitis from nickel in mobile phones.	2	36 (F)		Ericsson	2 + nickel (48, 96 hours)	not reported	Pazzaglia M, Lucente P, Vincenzi C, Tosti A.	Italy	Contact Dermatitis	2000 Jun;42(6):362-3.
2	Cellular phone dermatitis.	1	35 (F)		Ericsson	2 + nickel (48, 96 hours) 2 + 0.5%, 0.1%, 0.05% potassium dichromate (48, 72 hours)	DMG test + not reported	Seishima M, Oyama Z, Yamamura M.	Japan	Arch Dermatol.	2002 Feb;138(2):272-3.
3	Cellular phone dermatitis with chromate allergy.	8	54 (M)		not reported	1 + potassium dichromate	not reported	Seishima M, Oyama Z, Oda M.	Japan	Dermatology.	2003;207(1):48-50.
		32 (F)			not reported	1 + potassium dichromate; 1 + cobalt chloride	not reported				
		27 (F)			not reported	1 + potassium dichromate; 1 + nickel sulfate	not reported				
		19 (M)			not reported	1 + potassium dichromate; ? + nickel sulfate; ? + indium trichloride	not reported				
		25 (F)			not reported	2 + potassium dichromate; ? + cobalt chloride; ? + indium trichloride	not reported				
		18 (M)			not reported	1 + potassium dichromate	not reported				
		14 (M)			not reported	1 + potassium dichromate	not reported				
		14 (F)			not reported	2 + potassium dichromate	not reported				
4	Mobile telephone as new source for nickel dermatitis.	1	19 (F)	face, hands, upper extremities, umbilicus	SamsungSGH E 330	3 + nickel; 1 + thimerosal (48, 72 hours)	DMG +	Wöhrl S, Jandl T, Stingl G, Kinaciyan T.	Austria	Contact Dermatitis	2007 Feb;56(2):113.
5	Cellular phone addiction and allergic contact dermatitis to nickel.	1	25 (F)	face	not reported	2 + 5% nickel sulfate (48, 72 hours)	DMG +	Livideanu C, Giordano-Labadie F, Paul C.	France	Contact Dermatitis	2007 Aug;57(2):130-1.

(continued)

TABLE 1. (CONTINUED)

<i>Number</i>	<i>Title</i>	<i># Cases</i>	<i>Age (gender)</i>	<i>Distribution</i>	<i>Cell Phone Brand</i>	<i>Patch Test Results</i>	<i>Phone Testing</i>	<i>Authors</i>	<i>Country</i>	<i>Journal</i>	<i>Citation</i>
6	Cellphone contact dermatitis with nickel allergy.	1	18 (M)	face	Samsung	2 + nickel (72 hours)	DMG+	Luo J, Bercovitch L.	United States	CMAJ.	2008 Jan 1;178(1):23-4.
7	The outcome of dimethylglyoxime testing in a sample of cell phones in Denmark.	1	28 (F)	face	Siemens	nickel positive	DMG+	Thyssen JP, Johansen JD, Zachariae C, Menné T.	Denmark	Contact Dermatitis.	2008 Jul;59(1): 38-42.
8	Cell phone dermatitis.	1	32 (M)	face	not reported	2 + nickel	not tested	Madhukara J, Kumaran MS, Abraham A.	India	Indian J Dermatol Venereol Leprol.	2008 Sep-Oct; 74(5):500-1.
9	Nickel-induced facial dermatitis: adolescents beware of the cell phone.	3	15 (F)	face	not reported	2 + nickel	DMG+	Moennich JN, Zirwas M, Jacob SE.	United States	Cutis.	2009 Oct; 84(4):199-200.
10	Contact dermatitis to nickel related to cellular phone use.	1	13 (F) 18 (F) 25 (F)	face face face	not reported not reported not reported	1 + nickel 2 + nickel 3 +/3 + nickel sulfate; 2 +/3 + cobalt; 1 +/1 + palladium chloride at 48/72 hours	DMG+ DMG+ DMG+	Kluger N, Raison-Peyron N, Guillot B.	France	Presse Med.	2009 Nov;38(11): 1694-6.
11	Nickel allergy presenting as mobile phone contact dermatitis.	1	39 (M)	face	not reported	nickel positive	DMG+	Roberts H, Tate B.	Australia	Australas J Dermatol.	2010 Feb;51(1): 23-5.
12	An unusual case of cell phone dermatitis.	1	38 (M)	thigh	not reported	3 + nickel sulfate (48, 96 hours)	DMG+	Guameri F, Guameri C, Cannavò SP.	Italy	Contact Dermatitis.	2010 Feb;62(2):117.
13	Preauricular eczema: a sign of cellular phone dermatitis.	3	not reported not reported not reported	face face face	not reported not reported not reported	nickel and cobalt positive nickel and cobalt positive nickel and cobalt positive	not reported not reported not reported	Lee DY, Yang JM.	Korea	Clin Exp Dermatol.	2010 Mar;35(2):201-2.
14	Bilateral symmetrical contact dermatitis on the face and outer thighs from the simultaneous use of two mobile phones.	1	33 (M)	face, thigh	not reported	not tested	DMG+	Ozkaya E.	Turkey	Dermatitis.	2011 Mar-Apr; 22(2):116-8.

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TABLE 1. (CONTINUED)

<i>Number</i>	<i>Title</i>	<i># Cases</i>	<i>Age (gender)</i>	<i>Distribution</i>	<i>Cell Phone Brand</i>	<i>Patch Test Results</i>	<i>Phone Testing</i>	<i>Authors</i>	<i>Country</i>	<i>Journal</i>	<i>Citation</i>
15	Cell phone allergic contact dermatitis: case report and review.	1	28 (F)	face	Samsung	not tested	not tested	Rajpara A, Feldman SR.	United States	Dermatol Online J.	2010 Jun 15;16(6):9.
16	Cellular phone and accessory dermatitis due to nickel allergy: report of five cases.	5	12 (M)	face, neck	not reported	not tested	DMG+	Berk DR, Bayliss SJ.	United States	Pediatr Dermatol.	2011 May-Jun;28(3):327-31.
17	Unusual localization of cell phone dermatitis.	1	14 (F)	chest	not reported	nickel positive	DMG+	Suárez A, Chimento S, Tosti A.	United States	Dermatitis.	2011 Sep-Oct; 22(5):277-8
18	Allergic contact dermatitis caused by chromium in a mobile phone.	1	71 (M)	face, chest	Telstra T7	1 + potassium dichromate (48, 96 hours)	manufacturer confirmed plating chormate	Tan S, Nixon R.	Australia	Contact Dermatitis.	2011 Oct;65(4):246-7.
19	Breast eczema: mobile phones must not be overlooked.	1	17 (F)	chest	not reported	3 + nickel (48, 96 hours)	DMG+	Dannepond C, Armingtonaud P.	France	Ann Dermatol Venereol.	2012 Feb; 139(2):142-3.
20	Allergic contact dermatitis caused by a cell phone cover.	1	30 (F)	face	“silicone case”	2 +/2 +/2 + dry phone cover; 2 +/2 +/2 + wet phone cover; 2 +/1 +/1 + tricresyl phosphate; 2 +/2 +/? + p-tert-butyl-catechol; 1 +/1 +/? + Amerchol L101; 2 +/2 +/1 + wool alcohols (2/4/7 days)	not tested	Williams PJ, King C, Arslanian V.	United Kingdom	Australas J Dermatol.	2012 Feb;53(1):76-7.
21	Facial Contact Dermatitis and the Irritant Potential of Mobile Phone Screens.	1	15 (f)	face	LG GT360, Nokia 3600	1 + phone screens under occlusion, 1 + acetone screen extract	not tested	Valdivieso R, Heras-Mendaza F, Conde-Salazar L.	Spain	Pediatr Dermatol.	2012 Oct 2.

M, male; F, female; DMG, nickel dimethylglyoxime spot test.

TABLE 2. FOUR PUBLICATIONS REPORTING MOBILE PHONE SPOT TESTING

<i>Authors</i>	<i>Phone Release year</i>	<i>Make/Model; number tested</i>	<i>Nickel DMG Result</i>	<i>Cobalt Spot Test Result</i>	<i>Location (nickel;cobalt)</i>
Luo J, Bercovitch L 2008 n = 23 43% Ni +		BlackBerry 8700c	+	n/t	back
		BlackBerry Pearl	—	n/t	
		Kyocera KX444	—	n/t	
		LG Verizon VX8300	—	n/t	
		Motorola L2	+	n/t	headset
		Motorola Razr	+	n/t	headset
		Motorola SLVR	+	n/t	headset
		Motorola Q	+	n/t	headset
		Motorola i580	—	n/t	
		Motorola i870	—	n/t	
		Nokia 6061	—	n/t	
		Nokia 6062	—	n/t	
		Nokia 6820	—	n/t	
		Nokia 6230	—	n/t	
		Nokia 6682	—	n/t	
		Palm Treo 650	—	n/t	
		Samsung e105	+	n/t	around screen, menu button
		Samsung d807	+	n/t	menu button
		Sony Ericsson W600i	+	n/t	menu button
		Sony Ericsson W810i	+	n/t	menu button
		Sony Ericsson T610	+	n/t	handset
		Sony Z520a	—	n/t	
		Plantronics Explorer 320 bluetooth	—	n/t	
Thyssen et al. 2008 n = 41 20% Ni +	2004	Company 1*; 1	—	n/t	
	2004	Company 1*; 2	—	n/t	
	2004	Company 1*; 3	—	n/t	
	2004	Company 1*; 4	—	n/t	
	2004	Company 1*; 5	+	n/t	not reported
	2005	Company 1*; 6	+	n/t	not reported
	2005	Company 1*; 6	+	n/t	not reported
	2005	Company 1*; 6	+	n/t	not reported
	2005	Company 1*; 6	—	n/t	
	2005	Company 1*; 6	—	n/t	
	2006	Company 1*; 7	+	n/t	not reported
	2006	Company 1*; 8	—	n/t	
	2006	Company 1*; 9	—	n/t	
	2006	Company 1*; 10	—	n/t	
	2006	Company 1*; 11	—	n/t	
	2003	Company B*; 1	—	n/t	
	2004	Company B*; 2	—	n/t	
	2004	Company B*; 3	—	n/t	
	2004	Company B*; 4	—	n/t	
	2004	Company B*; 5	—	n/t	
	2005	Company B*; 6	—	n/t	
	2005	Company B*; 7	—	n/t	
	2005	Company B*; 8	—	n/t	
	2005	Company B*; 9	—	n/t	
	2005	Company B*; 10	—	n/t	
	2005	Company B*; 11	—	n/t	
	2006	Company B*; 12	—	n/t	
	2006	Company B*; 13	—	n/t	
	2006	Company B*; 14	+	n/t	not reported
	2006	Company B*; 15	—	n/t	
	2006	Company B*; 16	+	n/t	not reported
	2006	Company B*; 17	—	n/t	
	2006	Company B*; 18	—	n/t	
	2006	Company B*; 19	—	n/t	
	2006	Company B*; 20	—	n/t	
	2006	Company B*; 21	—	n/t	
	2007	Company B*; 22	—	n/t	

(continued)

TABLE 2. (CONTINUED)

<i>Authors</i>	<i>Phone Release year</i>	<i>Make/Model; number tested</i>	<i>Nickel DMG Result</i>	<i>Cobalt Spot Test Result</i>	<i>Location (nickel;cobalt)</i>
Jensen et al. 2011 n=50 18% Ni+	2007	Company B*; 23	+	n/t	not reported
	2007	Company B*; 24	—	n/t	
	2007	Company B*; 25	—	n/t	
	2007	Company B*; 26	—	n/t	
		Apple iPhone 4	—	n/t	
		Apple iPhone 3GS	—	n/t	
		BlackBerry 9700	—	n/t	
		Garmin Nüvifone A10	—	n/t	
		HTC Legend	+	n/t	power button
		HTC Wildfire	—	n/t	
		HTC Snap	+	n/t	metal bar
		HTC Tattoo	+	n/t	button, front
		HTC Smart	—	n/t	
		HTC Desire	—	n/t	
		HTC Desire HD	—	n/t	
		LG GT400	—	n/t	
		LG GT540	—	n/t	
		LG T320	—	n/t	
		Nokia C7	—	n/t	
		Nokia 6700 Classic	—	n/t	
		Nokia N8	—	n/t	
		Nokia 660	—	n/t	
		Nokia C5	—	n/t	
		Nokia 6600i	—	n/t	
		Nokia C6-00	—	n/t	
		Nokia E66	—	n/t	
		Nokia E52	—	n/t	
		Nokia 5230	—	n/t	
		Nokia 5800	—	n/t	
		Nokia N79	—	n/t	
		Nokia X6	—	n/t	
		Nokia 2730	—	n/t	
		Samsung S3370	—	n/t	
		Samsung LGH-L700	+	n/t	button, front
		Samsung GT-S3650	—	n/t	
		Samsung GTS8300	+	n/t	button, side
		Samsung SGH-i900	+	n/t	buttons, side
		Samsung S5350	—	n/t	
		Samsung SGH-F480	+	n/t	frame, back
		Samsung Galaxy si9000	+	n/t	headset jack, top
		Samsung SGH507	+	n/t	frame, back
		Sony Ericsson W595	—	n/t	
		Sony Ericsson U1i	—	n/t	
		Sony Ericsson U10i	—	n/t	
		Sony Ericsson Xperia x2	—	n/t	
		Sony Ericsson Xperia	—	n/t	
		Sony Ericsson W508	—	n/t	
		Sony Ericsson T700	—	n/t	
		Sony Ericsson J10i2	—	n/t	
		Sony Ericsson F100i	—	n/t	
		Sony Ericsson Xperia Mini	—	n/t	
		Sony Ericsson Vivaz Pro	—	n/t	
		Sony Ericsson W20 Xylo	—	n/t	
		Sony Ericsson J105i	—	n/t	
Aquino et al. 2013 total n=16 56% Ni+ 25% Co+		Apple iPhone 3GS (n=3)	—	—	
		Apple iPhone 4 (n=12)	—	—	
		Apple iPhone 4S (n=10)	—	—	
		Blackberry Bold 9650 (n=8)	+ **	—	keypad
		Blackberry Torch 9860 (n=1)	—	—	

(continued)

TABLE 2. (CONTINUED)

<i>Authors</i>	<i>Phone Release year</i>	<i>Make/Model; number tested</i>	<i>Nickel DMG Result</i>	<i>Cobalt Spot Test Result</i>	<i>Location (nickel;cobalt)</i>
		Blackberry Curve 8530 (n=4)	—	—	
		Blackberry Tour 9630 (n=4)	+ **	—	keypad
		Motorola Droid 2 A955 (n=9)	—	—	
		Motorola v265 (n=2)	+ **	—	middle button
		Motorola E815 (n=1)	+ **	+ **	middle button; middle button
		Motorola v950 (n=2)	—	0	
		LG VX4400 (n=7)	+ **	+ **	middle button, back of phone, side button; middle button, side button
		LG CV500 (n=1)	+ **	+ **	middle button, ear speaker; middle button
		LG VX6100 (n=1)	+ **	—	middle button
		Samsung SCH-A670 (n=6)	+ **	+ **	middle button, side button, back of phone; middle button
		Sony Ericsson Z520A (n=1)	+ **	—	middle button

*previously deidentified.

**at least 1 positive.

n/t, not tested.

by Jensen et al. highlights the release of nickel from the Apple iPhone5 case.⁴⁰

Mobile phone dermatitis and chromium allergy

Here we review cases of mobile phone dermatitis for chromium ACD. Of the 37 patients with mobile phone dermatitis, 10 patients had positive chromium patch test results.^{16,17,30} Six of these patients had tests implicating ACD to chromium alone, while the remaining four patients also demonstrated concomitant allergy with either nickel or cobalt. Seishima et al. reported the first case of ACD from a chromium-containing phone in 2002.¹⁶ The patient, a 35-year-old female, presented with left-sided preauricular pruritic dermatitis. She subsequently patch tested strongly positive for 0.05%, 0.1%, and 0.5% potassium dichromate but negative for 5% nickel, 2% aluminum chloride, 1% tin chloride, 2% iron chloride, 1% palladium chloride, 2% cobalt chloride, and several other metals. It was also confirmed that a component of her mobile phone was plated with chromium. A diagnosis of ACD caused by chromium was established, and her dermatitis spontaneously resolved 10 days after she discontinued use of the mobile phone.

The following year, in 2003, Seishima et al. published a report of eight additional cases of suspected chromium-induced mobile phone ACD.¹⁷ The patients, including four males and four females aged 14–54 years, all presented with auricular or preauricular facial dermatitis. In all eight patients, the patch test was strongly positive (+ +) or positive (+) for 0.5% of potassium dichromate at days 2 and 3. The patch test was also positive for 0.1% and 0.05% potassium dichromate, and a photo patch test showed the same results. Several of the patients also had positive patch test results to other metals. One patient was positive for 2% cobalt chlo-

ride and one patient for 5% nickel. Cobalt chloride, nickel, iridium trichloride, and iridium tetrachloride showed a possible reaction in one patient each. Following cessation of mobile phone use, all patients' dermatitis cleared within 10 days.

The third and final report describing chromium-related ACD from a mobile phone was published by Tan and Nixon in 2011.³⁰ The patient, a 71-year-old male, presented with left auricular and facial dermatitis, which had spread to his neck and chest. Patch testing showed a positive reaction to potassium dichromate at days 2 and 4. Upon contacting the manufacturer of the mobile phone, it was confirmed that chromium plating was used on the metallic components and buttons of the keypad. Efforts were made by the patient to decrease use of the phone, and subsequently the dermatitis resolved.

Mobile phone dermatitis and other allergens

Several published case studies on mobile phone dermatitis include allergens other than nickel and chromium. In 2012, Valdivieso et al. detailed an unusual case of dermatitis caused by a mobile phone.³⁴ The 15-year-old female patient presented with a persistent erythematous, polygonal dermatitis on her cheeks and chin. Mobile phone dermatitis was suspected. However, the patient patch tested negative for all allergens in the European standard series (including nickel, chromium, and cobalt), allergens of a plastic and glue series, various components of polyester, as well as 90 products and objects with which she had close contact. The only positive patch test was to a solution of a 1 cm² piece of her mobile phone screen in 10 mL acetone, indicating an allergy or possible irritancy to an unknown component of the mobile phone screen. Six months following cessation of use of her

mobile phone, no recurrence of the dermatitis had been noted.

The most recently reported case of facial dermatitis from a mobile phone was published by Williams et al. in 2012.³³ The patient, a 30-year old female, developed an acute vesicular dermatitis on her right cheek 1 week after purchasing a new “silicone” cover for her mobile phone. Subsequent patch testing with the British Contact Dermatitis Society standard series, the Plastics and Glue series, and the Rubber Additive Series did not reveal allergy to any metal components of the mobile phone, but did yield positive reactions to tricresyl phosphate, phenol formaldehyde, PTBC, amercol L101, wool alcohols, and to acetone extractions from her mobile phone cover. Discarding the mobile phone cover resulted in resolution of the dermatitis without recurrence.

Discussion

This review summarizes the main findings from published case studies on ACD caused by mobile phone and mobile phone accessories. The first two cases were reported by Pazzaglia et al. in 2000 in Italy,¹⁵ and Table 1 recounts 35 additional cases published subsequently, totaling 37 cases. Case reports have implicated chromium, iridium, cobalt, and plastics/glues as causes of ACD.^{16,17,27,29,33,34} The majority of mobile phone ACD was caused by metal allergens, notably nickel and chromium. In the four identified studies of DMG testing of mobile phones, excessive nickel release was identified in 18–45.5% of the tested products.^{20,21,35,37} Data on cobalt release from mobile phones are inconsistent, and cobalt release from mobile phones should continue to be investigated.^{38,39} A Danish clinical study conducted among dermatitis patients consecutively evaluated for nickel allergy between 2007 and 2009 also revealed that one third of mobile phones of nickel-allergic patients released nickel as assessed by DMG testing.⁴¹ While there currently is no evidence regarding the minimum exposure time required to sensitize and elicit allergic nickel dermatitis, the European Commission defined long-term exposure as >30 minutes of continuous skin contact and/or >1 hour discontinuously in total per day.⁴² As mobile phones become more popular and as smartphones with more features continue to gain popularity, it is reasonable to expect these time limits to be achieved or surpassed by users.

Revision of laws limiting allergen content and release for, for example, nickel is a step in the right direction. However, at present, they appear to be inadequate at limiting allergen content in consumer goods such as mobile phones. Despite the 2009 addition of mobile phones to the EU Nickel Directive, rates of DMG test positive phones in Denmark seemed to be unchanged between 2008 and 2011.^{21,37} As mobile phone use continues to rise in popularity among all economic groups, nickel exposure due to mobile phones will continue to rise, which may put consumers at risk for ACD. In the span of one decade, reports of mobile phone dermatitis rose from 2 in 2000¹⁵ to 27 in 2010,^{2,16–27} an increase of 1,250%. In the 2 years following that, 11 additional cases were reported,^{28–34} showing an increase of 40% from 2010 to 2012.

Pertinently, among 34 patients whose age was reported in the literature, 14 (41.2%) were aged 18 years or youn-

ger.^{2,17,18,20,29,31,32,34} It is likely that mobile phone dermatitis is underreported, especially among pediatric patients.²⁹ The incidence of adolescents using mobile phones is on the rise,² and nickel, a common metal allergen found in mobile phones,¹⁰ is the most common allergy found in patch-tested children.⁴³ With the increased use of smartphones, which include not only phone capabilities but also e-mail, texting, Internet, and gaming functionalities, it is likely that greater numbers of young adults will develop mobile phone ACD.

As worldwide rates of mobile phone use rise, we here show that cases of mobile phone associated ACD are also increasing. Despite efforts to control allergen release in phones, many phones on the market release levels of metals such as nickel that are sufficient to induce ACD. Among both adult and pediatric populations, it is important to suspect this diagnosis when evaluating patients with dermatitis of the face, neck, hands, breasts, or anterior thighs. A known history of metal allergy should increase the index of suspicion for nickel- or chromium-induced mobile phone ACD. Patch testing for common metal allergens and spot testing of the patient's phone may be helpful in establishing a diagnosis.

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