Mobile Phones: Potential Sources of Nickel and Cobalt Exposure for Metal Allergic Patients

Marcella Aquino, MD, Tania Mucci, MD, Melanie Chong, MD, Mark Davis Lorton, MD, and Luz Fonacier, MD

The use of cellular phones has risen exponentially with over 300 million subscribers. Nickel has been detected in cell phones and reports of contact dermatitis attributable to metals are present in the literature. We determined nickel and cobalt content in popular cell phones in the United States. Adults (>18 years) who owned a flip phone, Blackberry, or iPhone were eligible. Seventy-two cell phones were tested using SmartPractice’s commercially available nickel and cobalt spot tests. Test areas included buttons, keypad, speakers, camera, and metal panels. Of the 72 cell phones tested, no iPhones or Droids tested positive for nickel or cobalt. About 29.4% of Blackberrys [95% confidence interval (CI), 13%–53%] tested positive for nickel; none were positive for cobalt. About 90.5% of flip phones (95% CI, 70%–99%) tested positive for nickel and 52.4% of flip phones (95% CI, 32%–72%) tested positive for cobalt. Our study indicates that nickel and cobalt are present in popular cell phones. Patients with known nickel or cobalt allergy may consider their cellular phones as a potential source of exposure. Further studies are needed to examine whether there is a direct association with metal content in cell phones and the manifestation of metal allergy.

Introduction

The use of cellular phones has risen exponentially over the last 10 years, accounting for an estimated 178 billion dollars spent annually on cell phone services and over 875 billed minutes per month in the United States in 2010. In addition to talking on the phone, national surveys reveal that people use cell phones for a wide range of activities, including texting, emailing, web browsing, game playing, and listening to music. The Cellular Telecommunications Industry Association (CTIA) reported that Americans sent and received 565 messages per month in 2010, a fourfold increase from 2007. The National Health Interview Survey from the CDC reported that 3 out of every 10 American homes use a mobile phone as their primary phone.

A European group sought to determine the amount of nickel released from popular cell phones. They reported that 8 out of 41 cell phones (19.5%) tested positive for dimethylglyoxime (DMG), indicating that the item released >0.5 μg nickel/cm²/week. The European Union (EU) Nickel Directive, which was instated in 1994 to reduce nickel release from consumer items, was revised in 2009 to include nickel-releasing cell phones.

Nickel is the most common allergen found among patch-tested patients. In a recent follow up to the Odense Adolescence Cohort Study, 11.4% of respondents reported that they had eczematous dermatitis to metal contact (buttons, buckles, jewelry). After the implementation of nickel regulation in the EU, nickel sensitization was significantly less among younger age groups, particularly in women. In contrast to the findings in Europe, the prevalence of nickel allergy has increased steadily among all age groups in the United States. A recent epidemiologic study of nickel allergy in America and China found a significant increase in the prevalence of nickel allergy in the U.S. since 1970; a significant increase in the prevalence of nickel allergy in China was also seen. The development of dermatitis by means of nickel sensitization occurs through prolonged cutaneous exposure from items such as jewelry, tools, coins, watches, and belt buckles. The European Commission proposed prolonged contact as greater than 30 min of continuous or more than 1 h total of discontinuous skin contact in a day. It has been reported that individuals spend ~50 min a day using cell phones in the United States.

The clinical relevance of metal content in cell phones leading to contact dermatitis has been suggested by several case reports (Tables 1 and 2), with 24 cases attributable to nickel allergy and the remainder secondary to chromates. The majority of these cases were characterized by pruritic, eczematous papules and plaques on the lateral cheeks and/or preauricular area. The dermatitis typically presented unilaterally and in an irregular shape. However, other less common sites included the thighs (from cell phones kept in pant pockets) and in one case between the breasts (this was...
where the patient housed her phone); a high index of suspicion is needed particularly in these less prevalent locations.\textsuperscript{22,35}

In cases where DMG testing was performed on the suspected cell phone, all results were positive. Discontinuing use of the cell phone led to resolution of the dermatitis.\textsuperscript{23,26,28,32} In reports where the phone was not discontinued, the use of plastic films, casings, and belt pouches also led to an improvement of the dermatitis.\textsuperscript{22,29,30} One study testing 22 cell phones and a Bluetooth headset found that the most common cell phone sites that contain free nickel are menu buttons, metal frames around the LCD display, and decorative logos on the headset. This group suggested that covering these areas may help to prevent or improve cell phone contact dermatitis in nickel-allergic patients.\textsuperscript{26}

Cobalt coexists with nickel in nature and is often seen as an impurity in nickel-containing products.\textsuperscript{16} The prevalence of cobalt allergy is estimated to be in 1\% of the general population.\textsuperscript{38} Historically, isolated cobalt allergy is seen in metal workers, brick layers, and pottery workers through occupational exposure.\textsuperscript{39} However, a study conducted in the United States from 2001 to 2004 revealed that 12\% of children with dermatitis had a relevant cobalt allergy.\textsuperscript{40} Although a decrease in nickel sensitization was seen after the implementation of regulations in Europe, the prevalence of cobalt allergy remained the same.\textsuperscript{14–17,39,41} A study performed in Denmark to determine whether cobalt had replaced nickel in jewelry after the implementation of the EU Nickel Directive showed that cobalt was detected in only 1.1\% of the items.\textsuperscript{42} Another study looked at the cobalt

<table>
<thead>
<tr>
<th>Report date</th>
<th>Age/sex</th>
<th>Country</th>
<th>Patch test results</th>
<th>DMG testing of phone</th>
<th>Dermatitis improved with reduced contact?</th>
<th>Ref.</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>36 F</td>
<td>Italy</td>
<td>Nickel positive</td>
<td>Not stated</td>
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<td>25 F</td>
<td>France</td>
<td>2+ Nickel</td>
<td>Positive</td>
<td>Yes</td>
<td>25</td>
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<tr>
<td>2008</td>
<td>18 M</td>
<td>USA</td>
<td>Nickel positive</td>
<td>Positive (headset)</td>
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<td>2008</td>
<td>32 M</td>
<td>India</td>
<td>2+ Nickel</td>
<td>Not performed</td>
<td>Yes</td>
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<tr>
<td>2009</td>
<td>15 F</td>
<td>USA</td>
<td>2+ Nickel</td>
<td>Positive</td>
<td>Yes</td>
<td>28</td>
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<tr>
<td>2009</td>
<td>13 F</td>
<td>USA</td>
<td>1+ Nickel</td>
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<td>23</td>
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<tr>
<td>2009</td>
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<td>USA</td>
<td>2+ Nickel</td>
<td>Positive</td>
<td>Yes</td>
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<td>3 Pts</td>
<td>Korea</td>
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<td>Australia</td>
<td>Nickel positive</td>
<td>Positive</td>
<td>Yes</td>
<td>32</td>
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<tr>
<td>2010</td>
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<td>Italy</td>
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<td>Positive</td>
<td>Yes</td>
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<td>USA</td>
<td>Not stated</td>
<td>Not stated</td>
<td>Yes</td>
<td>31</td>
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<tr>
<td>2011</td>
<td>12 M</td>
<td>USA</td>
<td>All with prior history of nickel sensitivity</td>
<td>All positive</td>
<td>Yes (patient 1)</td>
<td>21</td>
</tr>
<tr>
<td>17 F</td>
<td></td>
<td></td>
<td></td>
<td>Except patient 4</td>
<td>Unknown</td>
<td></td>
</tr>
<tr>
<td>16 F</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Unknown</td>
<td></td>
</tr>
<tr>
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<tr>
<td>14 F</td>
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<td></td>
<td></td>
<td></td>
<td>Unknown</td>
<td></td>
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<td>Turkey</td>
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<td>Yes</td>
<td>29</td>
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<tr>
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<td>14 F</td>
<td>USA</td>
<td>Nickel positive</td>
<td>Positive</td>
<td>Unknown</td>
<td>35</td>
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</table>

DMG, dimethylglyoxime; Pts, patients; M, male; F, female.

<table>
<thead>
<tr>
<th>Report date</th>
<th>Age/sex</th>
<th>Country</th>
<th>Patch test results</th>
<th>Improvement of dermatitis after reducing contact?</th>
<th>Ref.</th>
</tr>
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<td>2002</td>
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<td>Japan</td>
<td>2+ Potassium dichromate</td>
<td>Yes</td>
<td>34</td>
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<tr>
<td>2003</td>
<td>54 M</td>
<td>Japan</td>
<td>All positive to potassium dichromate; Pt 3 also 1+ nickel and Pt 2 also 1+ cobalt</td>
<td>All improved</td>
<td>33</td>
</tr>
<tr>
<td>2011</td>
<td>71 M</td>
<td>Australia</td>
<td>1+ Potassium dichromate</td>
<td>Yes</td>
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release from cell phones. Of the randomly selected sample of 50 new mobile phones for sale, no cobalt release was detected. Interestingly, there have been four cases of patients with cell phone dermatitis deemed to have both nickel and cobalt sensitivity on patch testing, whose dermatitis improved with reduced cellular phone contact, however, the cellular phones were not tested for cobalt.

Given the rise in nickel and cobalt sensitization and reports of cell phone dermatitis in the literature, our aim was to investigate whether nickel or cobalt was present in top selling cellular phone models in the United States.

Methods

Phone selection

Phones from top selling models determined by comScore MobiLens data were selected for our study (Table 3). Wherever possible, multiple phones of the same model were included for testing. Table 4 contains a complete list of cellular phones tested in this study.

Patient selection

Adults over the age of 18 who owned one of the listed phones were invited to contribute one or more phones for testing. IRB approval was obtained from the Winthrop University Hospital with oral informed consent from each participant.

Phone testing

Phones were tested using SmartPractice’s Reveal and Conceal Nickel and Cobalt Spot Test Kits. A total of five areas per phone were tested, including the camera, keypad, metal logo, side panels, and speakers. All areas tested were recorded and are reported. Each area was swabbed first with the nickel cotton-tipped plastic applicator for 30–60 seconds, and a positive test was determined by a change in the applicator tip from white to light pink or strawberry red (Fig. 1). A reaction was reported as negative if no color change was observed. A known nickel containing coin was used as a positive control, and a non-nickel containing plastic case served as a negative control. The nickel spot test was followed by the cobalt spot test performed at a different site. The reagent for nickel was DMG, and the reagent for cobalt was 1-nitroso naphthol 3,6 disulfonic acid disodium salt. The cobalt spot test becomes positive when cobalt is released at *8 ppm. To minimize the risk of false positives, after testing with one reagent, the phone was wiped down with a dry cloth and tested with the second reagent. For each spot test, different areas of the cell phones were tested. All positive tests were confirmed and repeated on separate days.

Literature review

A search for peer reviewed literature using the PubMed search engine was performed using the following keywords:
cell phone, mobile phone, dermatitis, allergic contact dermatitis, cell phone allergy, nickel and cobalt dermatitis, and consumer item allergy. Studies and case reports discussing dermatitis due to cell phones and attributable to metal allergy were included for review.

Results

A total of 72 cell phones from seven different manufacturers were tested. We found that 24 of 72 cell phones [33%; 95% confidence interval (CI), 24%–45%] tested positive to nickel using DMG. Ten out of 72 phones (14%; 95% CI, 8%–24%) tested positive for cobalt, all of which were flip phone middle buttons. In addition, two of seven side buttons were positive for cobalt in the LG VX400/C210 model. All of the Samsung SCH670/C210 models (6/6) were cobalt positive.

Of the 24 phones with nickel positivity, 20.8% were Blackberrys/C210 and 79.2% were flip phones. Of the five Blackberrys that tested positive, four were model Bold 9650 (four of eight tested positive for nickel) and one was model Curve 9630 (one of four phones tested positive for nickel). In the flip phone category, 90.5% of phones tested positive for nickel. In the flip phone category, 90.5% of phones tested positive for nickel (95% CI, 70%–99%), with the middle button and back of the phone the most common sites of nickel release. Only one flip phone tested negative for nickel, the Motorola v950, a rubber-coated sports model. Of the 25 iPhones/C210 and 9 Motorola Droid A955 models tested, none were positive for nickel or cobalt. Table 4 contains a complete list of phone results.

Discussion

Previous studies performed in Europe demonstrated nickel positivity in 18%–26% of mobile phones tested, with rates of nickel sensitivity higher in conventional or nonsmart phones (Table 5). One study in the United States in 2008 found that 10 of 22 (45%) mobile phones tested positive for nickel. Our results are similar in that conventional cell phones (nonsmart phones) tested positive for nickel, with nickel positivity in our study higher than that detected in Europe, but lower than the previous study conducted in the United States.

Our study indicates that nickel and cobalt are present in popular cell phones, particularly flip phones. This is the first study to demonstrate cobalt positivity in cellular phones. About a third of Blackberrys tested, but no iPhones or Droids tested, had detectable nickel or cobalt. Although none of the 25 iPhones we tested were found to release either nickel or cobalt by means of the spot test in our study, there is a report of an iPhone 5 model testing positive to nickel through DMG testing49 and Apple MacBook Pro laptops50,51 testing positive to nickel using DMG in the literature.

It is important to note, however, that we did not correlate a patient’s clinical history with cell phone type or the development of dermatitis. Evaluation of cell phones in patients with known nickel or cobalt allergic contact dermatitis would better demonstrate whether phone use correlates directly with contact allergy or sensitization.

Nickel positivity was found in phones with keypads, while none of the touch screen models were positive. Interestingly, the Blackberry models that tested positive for nickel had significant wear on the keypad (Fig. 2). We suspect that the surface coating may initially prevent the release of nickel from keypads, but wear may lead to nickel exposure. Another hypothesis is that consumer products that release nickel may do so due to treatment with nickel coating substances as was recently found on a laptop computer50 that released between 0.2 and 0.3 μg nickel/cm² of nickel per week depending on the area tested (bottom surface, hand rest).

The cellular phone models tested in our study differ from those previously evaluated. Additionally, our study was unique in that wherever possible, multiple phones of the same make were tested. Despite this, there was still variability among phones of the same model. This may be due to
the use of different suppliers for cell phone parts based on the price and availability. Thus, the finding of nickel in a small number of phone models cannot be extrapolated to the millions of phones found worldwide. Although this study is the largest to date, testing more phones of the same model would allow a better understanding of the degree of variability within a single cell phone model. Assessing the same phone after time has elapsed may provide insight into our theory regarding age or wear of the phone contributing to a positive test.

No cell phone accessories were tested in our study. Future investigations on metal release from phone accessories, such as cases, adaptors, and headsets, may identify additional sources of metal exposure. Additionally, other known contact allergens such as rubber, acrylates, and polyurethane components of mobile phones also warrant investigation.

The hallmark of treatment for allergic contact dermatitis is avoidance. Patients with known nickel or cobalt allergy should consider their cellular phones as a potential source of exposure. This is particularly important as more and more people are using their cell phones as their primary phones and laptops/tablets as their primary computers, which result in a greater amount of skin exposure to nickel and other metals. This change is occurring not only during personal time, but also during educational activities as tablets and computers are being utilized as teaching tools. It is essential that the public is aware that sensitization can occur through exposure and that commonly used everyday products contain nickel. Legislation to control nickel release in the United States may help decrease the prevalence of nickel allergy as it has done in Europe.

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Author Disclosure Statement

All the authors declare that they have no conflict of interests.

References


