Infections associated with body modification

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Although exact statistics are lacking, body modifications for cosmetic purposes are performed in many countries. The commonest forms include tattooing, body piercing, and breast and facial augmentation using implants or injectable fillers. Liposuction and, to a lesser extent, mesotherapy are also practiced in many countries. Infective complications of these procedures include local infections, transmission of bloodborne pathogens (viral hepatitis and human immunodeficiency virus), and distant infections such as infective endocarditis. Presence of foreign bodies, long healing time of piercing wounds, and poor compliance with infection control practices of some practitioners all predispose the recipients to infections. Apart from the endogenous microbial flora of the skin and mucosae, atypical mycobacteria, especially the rapid growers, have emerged as some of the most important pathogens in such settings. Outbreaks of infection are commonly reported. We hereby review the current knowledge of the topic with specific focus on infections associated with tattooing, body piercing, breast augmentation, mesotherapy, liposuction, and tissue filler injections. Greater awareness among consumers and health-care professionals, as well as more stringent regulations by the health authorities, is essential to minimize the health risks arising from these procedures.

Introduction

Body modification or body art for nontherapeutic purposes encompasses a vast variety of procedures, ranging from common procedures such as tattooing, body piercing, subdermal and transdermal implantation, and breast augmentation, to more drastic procedures such as tongue splitting, genital modification, and gender reassignment surgery. There are few formal statistics on the prevalence of body modification in most parts of the world. In a study of undergraduates in the United States, the prevalence of body piercing and tattooing was found to be 51% and 23%, respectively.1 In Europe, the prevalence of tattooing has been reported to be 6–12% in different studies, and that of body piercing about 20% in some studies.2,3 Similarly, the incidence or risk of infective complications following these
procedures is unknown. This is due to the fact that there is no information on the denominator of persons who have received these procedures, and that cases reported in the literature tend to be isolated case reports or well-documented outbreaks. The vast majority of individuals who went for tattooing or body piercing had not considered the potential health risks prior to the procedures. In most countries, practitioners of body modification and body art parlors are not strictly regulated by law, and therefore stringent adherence to the recommended infection control practice is sometimes doubtful. Persons embracing body modifications sometimes also engage in other risky behaviors such as illicit drug use and alcoholism, which may predispose them to other infectious complications.

Body modification procedures can be complicated by local pain, inflammation, infection. Circumstances predisposing individuals to infections after body modification are manifold. Various microbial and environmental factors contribute to the transmission of microbial pathogens during body modification procedures. Since these procedures inevitably involve breaches in the skin or mucosae, pathogens can be introduced from the normal flora colonizing the surfaces or from exogenous microbes such as contaminated instruments, jewelry, and disinfectants. These infecting organisms can sometimes cause infections in distant organs. Organisms such as Pseudomonas aeruginosa and atypical mycobacteria are ubiquitous in the environment. Their resistance to and ability to contaminate low-level disinfectants and antiseptics have been well documented. Other major concerns are bloodstream infections such as viral hepatitis and human immunodeficiency virus (HIV) infection. High-level viremia can be encountered in patients with hepatitis B virus (HBV) and HIV infections, and even severe infections with blood or body fluids can result in infections if disinfection of the environment and instruments is inadequate. The prolonged survival of hepatitis C virus (HCV) in the environment may also contribute to its transmission under such circumstances.

In many countries, body modification procedures performed in parlors are not subjected to strict hygienic regulations. The majority of these "minor" procedures are performed in commercial premises or by unlicensed personnel, sometimes with strict adherence to infection control guidelines. Sterilization and disinfection of instruments between clients, choice of maintenance of chemical disinfectants and antiseptics, and adoption of a particular infection control practice (such as maintenance of a sterile field, prevention of cross-contamination, and disposal of biohazardous wastes) often depend on the conscientiousness of the premise owners and operators. A number of outbreaks related to such procedures have been reported in recent years (Table 1).

**Tattooing**

In the process of tattooing, colored inks are introduced into the skin dermis by electrically driven needles. Local and systemic health problems are common after tattooing, which persist even for weeks after the procedure. Infecive complications may result from the cross-contamination of inadequately sterilized equipment and contaminated tattoo inks. Reported infections, which were sometimes associated with outbreaks in the tattoo recipients, include tuberculosis (lupus vulgaris), leprosy, verruca vulgaris and verruca plana due to human papillomaviruses, zygomycosis, community-associated methicillin-resistant Staphylococcus aureus, and atypical mycobacteria, especially the rapid growers. Noninfective causes of local skin reactions to tattoos, including allergic, granulomatous, and lichenoid reactions or coincidental lesions such as malignancies, should also be considered as differential diagnoses.

Exposure to bloodborne pathogens poses a major infectious risk to persons receiving tattoos. Although syphils used to be a common infection transmitted during tattooing, it is relatively uncommon nowadays. One of the largest outbreaks of HBV infection affected 34 persons of whom 31 were tattooed by one artist and three were secondary cases. Epidemiological studies have shown tattooing to be a risk factor for HCV infection, and a dose-related response was noted. In contrast to HCV infection acquired from blood product transfusion, that acquired from tattooing is often subclinical, probably reflecting the smaller inoculum of viruses transferred in such settings. Tattooing has been shown to be a risk factor for HIV infection in some studies, but not in others, possibly due to the confounding effects of various at-risk behaviors in this group of individuals. However, a recent case of HIV infection in an Australian tourist after receiving tattoos in Bali again raised the possibility of HIV transmission in such settings.

**Body piercing**

Body piercing involves puncturing of the skin or mucosae with subsequent insertion of foreign bodies, such as rings, bars, or other jewelry. In some procedures, the cartilage is also pierced, as in case of "high piercing" of the ear involving the cartilage of the pinna. Common sites of piercing include ears, eyebrows, lips, navel, nipples, genitalia, nose, tongue, and other parts of the oral mucosa. As the case of tattooing, body piercing can be associated with transmission of bloodborne pathogens. Local inoculation of pathogens has likewise resulted in the transmission of tuberculosis (lupus vulgaris) and tetanus. Bacterial infections of the skin and soft tissues tend to be commoner in body piercing than in tattooing because of the greater degree of tissue damage, presence of deeper wounds, and placement of foreign bodies (jewelry) in the wounds in the former case. One important contributing factor is the long healing time of the wound after piercing, which may take up to 6–9 months in some
<table>
<thead>
<tr>
<th>Procedure</th>
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<th>Location</th>
<th>Number of patients with infective complications</th>
<th>Type(s) of infection</th>
<th>Organism(s) involved</th>
<th>Important epidemiological characteristics</th>
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</thead>
<tbody>
<tr>
<td>Tattooing</td>
<td>NA</td>
<td>Germany</td>
<td>7</td>
<td>Skin infection, granulomatous and purulent</td>
<td><em>Mycobacterium</em> spp., possibly related to <em>Mycobacterium haemophilum</em></td>
<td>Eyebrow tattoos by the same tattooist using Chinese tattoo ink; onset days to weeks after tattooing; all had local lymphadenopathy</td>
<td>10</td>
</tr>
<tr>
<td>Tattooing</td>
<td>2004–2005</td>
<td>Ohio, Kentucky, Vermont, USA</td>
<td>44</td>
<td>Skin abscesses</td>
<td>Community-associated methicillin-resistant <em>Staphylococcus aureus</em></td>
<td>44 recipients in six unlinked clusters from 13 unlicensed tattooists in three states; onset within 4–22 d; skin lesions were present in some tattooists</td>
<td>11</td>
</tr>
<tr>
<td>Tattooing</td>
<td>2007–2008</td>
<td>Germany, Austria, Switzerland</td>
<td>0.4%–1.2%</td>
<td>Pustular skin lesions</td>
<td>NA</td>
<td>Fever</td>
<td>2</td>
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<tr>
<td>Tattooing</td>
<td>2007–2008</td>
<td>Minnesota, USA</td>
<td>6</td>
<td>Skin infection</td>
<td><em>Mycobacterium chelonae</em></td>
<td>All received tattoos by the same tattooist; onset within 1–2 wk; environmental cultures negative; original ink not available for culture</td>
<td>12</td>
</tr>
<tr>
<td>Tattooing</td>
<td>2011</td>
<td>USA</td>
<td>14 confirmed cases, 4 probable cases, 1 suspected case</td>
<td>Skin infection</td>
<td><em>M. chelonae</em>, <em>Mycobacterium abscessus</em></td>
<td><em>M. chelonae</em> also isolated from unopened bottles of tattoo ink, with identical PFGE patterns as patients’ isolates</td>
<td>13</td>
</tr>
<tr>
<td>Nipple piercing</td>
<td>Literature review</td>
<td>Literature review</td>
<td>12</td>
<td>Breast abscess</td>
<td><em>Streptococcus pyogenes</em>, <em>Streptococcus agalactiae</em>, coagulase-negative staphylococci, anaerobes, <em>M. abscessus</em>, <em>Mycobacterium fortuitum</em></td>
<td>Incubation period 2 wk to 12 mo</td>
<td>14</td>
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</thead>
<tbody>
<tr>
<td>Ear piercing</td>
<td>2000</td>
<td>Oregon, USA</td>
<td>7 confirmed, 18 suspected cases</td>
<td>Auricular chondritis and ear lobe infection</td>
<td>P. aeruginosa, S. aureus from one case with ear lobe infection</td>
<td>118 customers of a jewelry kiosk interviewed; improper practices noted; P. aeruginosa isolated from some of the staff and from an atomizer solution containing a mixture of quaternary ammonium and phenolic disinfectant, which had been refilled repeatedly; cartilage piercing associated with a higher risk of infection</td>
<td>15</td>
</tr>
<tr>
<td>Oral piercing</td>
<td>1966–2009</td>
<td>Literature review</td>
<td>18</td>
<td>Infective endocarditis (8), Ludwig’s angina (2), tongue abscess (1), glossitis (1), cephalic tetanus (1), cerebellar abscess (1), lymphadenitis (2), sialadenitis (1), dental abscess with neck extension (1), chorioamnionitis (1)</td>
<td>Endocarditis cases: Neisseria mucosa (1), Haemophilus aphrophilus (1), S. aureus (2), oral streptococci (3), Gemella (1); other infections: oral streptococci, Eikenella corrodens, Lactobacillus, anaerobes, Actinomyces</td>
<td>No fatal cases reported</td>
<td>16</td>
</tr>
<tr>
<td>Oral piercing</td>
<td>2002–2003</td>
<td>Ghent, Belgium</td>
<td>13</td>
<td>History of symptoms suggestive of infection</td>
<td>NA</td>
<td>50 persons attending a dental clinic surveyed; average duration of oral piercing 12.6 mo</td>
<td>17</td>
</tr>
<tr>
<td>Oral piercing</td>
<td>2002–2008</td>
<td>Emergency departments, USA</td>
<td>9926</td>
<td>Infection at piercing site</td>
<td>NA</td>
<td>24,459 with oral piercing-related injuries</td>
<td>18</td>
</tr>
<tr>
<td>Ear piercing</td>
<td>2003</td>
<td>New York, USA</td>
<td>15</td>
<td>Auricular chondritis</td>
<td>P. aeruginosa</td>
<td>Outbreak associated with the same piercing facility; incubation</td>
<td>19</td>
</tr>
<tr>
<td>Procedure</td>
<td>Year</td>
<td>Location</td>
<td>Sample Size</td>
<td>Complications</td>
<td>Organism(s)</td>
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<tr>
<td>Oral piercing</td>
<td>2005</td>
<td>Strasbourg, France</td>
<td>6</td>
<td>Any infective complication</td>
<td>NA</td>
<td></td>
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<tr>
<td>Oral piercing</td>
<td>2009</td>
<td>Belém, Brazil</td>
<td>16</td>
<td>Purulent discharge</td>
<td>NA</td>
<td></td>
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<tr>
<td>Breast implants, cosmetic and reconstructive</td>
<td>1964–1991</td>
<td>Minnesota, USA</td>
<td>19 patients, 21 breasts</td>
<td>Wound infection</td>
<td>NA</td>
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<tr>
<td>Breast augmentation and face lift</td>
<td>1985</td>
<td>USA</td>
<td>8</td>
<td>Surgical wound infection</td>
<td>Culture positive for <em>M. abscessus</em> in five cases</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Breast implants, cosmetic</td>
<td>2003</td>
<td>Israel</td>
<td>15</td>
<td>Surgical site infection</td>
<td><em>Mycobacterium jacuzzii</em></td>
<td></td>
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<tr>
<td>Breast implants, cosmetic</td>
<td>1999–2007</td>
<td>Denmark</td>
<td>63/80, 67/81, 35/38 women/implants within 30 d, 3 y, and 5 y, respectively.</td>
<td>Wound infection and periprosthetic infection</td>
<td>NA</td>
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</table>

Period 1–13 d; risk factors for infection: helix piercing and use of aftercare solution; *P. aeruginosa* isolated from aftercare solution containing benzalkonium chloride. Questionnaire survey of 201 individuals with current oral and perioral piercings only.

Oral piercing 2005 Strasbourg, France

Oral piercing 2009 Belém, Brazil

Breast implants, cosmetic and reconstructive 1964–1991 Minnesota, USA

Breast augmentation and face lift 1985 USA

Breast implants, cosmetic 2003 Israel

Breast implants, cosmetic 1999–2007 Denmark

749 cases recruited from one institute: cosmetic 532, reconstructive 125, prophylactic 92; overall complication rate: reconstructive > prophylactic > cosmetic surgery. Contaminated gentian violet solution used for skin marking by the same surgeon; also culture positive for *M. abscessus*.

Breast implants, cosmetic 2003 Israel

Breast implants, cosmetic 1999–2007 Denmark

Primary cosmetic implantation, 5130/10,252 women/implants; primary implantation for breast anomalies, 243/388 women/implants.

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<tbody>
<tr>
<td>Breast implants, cosmetic</td>
<td>1999–2002</td>
<td>Denmark</td>
<td>6/6 patients/implants (initial); 4/5 patients/implants (subsequent)</td>
<td>Wound infection</td>
<td>NA</td>
<td>Cohort with 1946 persons, 3390 primary implantations, 454 subsequent implantations</td>
<td>26</td>
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<td></td>
<td>2/2 patients/implants (initial); 0/0 patients/implants (subsequent)</td>
<td>Periprosthetic infection</td>
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<td>33</td>
<td>Surgical site infection</td>
<td>NA</td>
<td>3002 women; onset of infection 22 ± 12.8 d; Reduced risks associated with Mentor prostheses, and use of antiseptics and antibiotics; increased risk associated with use of drains</td>
<td>27</td>
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<td></td>
<td></td>
<td>2/2 patients/implants (initial); 0/0 patients/implants (subsequent)</td>
<td>325 patients: expander/implants, 79 patients; pedicle TRAM flaps, 179 patients; free TRAM flaps, 67 patients</td>
<td>28</td>
</tr>
<tr>
<td></td>
<td>2005–2007</td>
<td>Genoa, Italy</td>
<td>16</td>
<td>Implant-associated infections</td>
<td>S. aureus (4), coagulase-negative staphylococci (2), S. agalactiae (1), Serratia marcescens (2), Enterobacter cloacae (1), P. aeruginosa (3), Acinetobacter baumannii (1), culture negative (4)</td>
<td>240 breast cancer patients reviewed; onset 2–239 d; higher risk in patients receiving radiotherapy after surgery</td>
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<td>14/16 patients/implants (initial); 3/3 patients/implants</td>
<td>Cohort with 574/901 patients/implants; 407/484 patients/implants enrolled at initial implantation, 302/417 patients/implants enrolled at</td>
<td>30</td>
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<tr>
<td>Procedure</td>
<td>Years</td>
<td>Location</td>
<td>Infections</td>
<td>Sites</td>
<td>Complications</td>
<td>Description</td>
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<tr>
<td>Injected PAAG augmentation mammoplasty</td>
<td>1997–?</td>
<td>China</td>
<td>2</td>
<td>Infec</td>
<td>Infection</td>
<td>NA</td>
<td></td>
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<tr>
<td>Injected PAAG augmentation mammoplasty</td>
<td>1999–2003</td>
<td>China</td>
<td>8</td>
<td>Infec</td>
<td>Infection</td>
<td>NA</td>
<td></td>
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<tr>
<td>Injected PAAG augmentation mammoplasty</td>
<td>2000–2003</td>
<td>China</td>
<td>6</td>
<td>Infec</td>
<td>Infection</td>
<td>NA</td>
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<tr>
<td>Injected PAAG augmentation mammoplasty</td>
<td>2005–2008</td>
<td>China</td>
<td>6</td>
<td>Infec</td>
<td>Infection</td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td>Injected PAAG soft tissue augmentation</td>
<td>1997–2008</td>
<td>Iran</td>
<td>11</td>
<td>Infecc</td>
<td>Infection and abscesses</td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td>Mesotherapy</td>
<td>2004–2005</td>
<td>Colombia</td>
<td>15</td>
<td>Skin inf</td>
<td>M. chelonae (5), nontuberculous mycobacteria (6), culture negative (4)</td>
<td>Incubation period 1–12 wk</td>
<td></td>
</tr>
<tr>
<td>Mesotherapy</td>
<td>2004–2005</td>
<td>Colombia</td>
<td>70</td>
<td>Skin inf</td>
<td>Culture positive in 29 cases: M. chelonae (26), M. abscessus (2), M. fortuitum (1)</td>
<td>Incubation period 8–60 d; 66% of the cases received mesotherapy from one practitioner</td>
<td></td>
</tr>
<tr>
<td>Mesotherapy</td>
<td>2004–2005</td>
<td>Peru</td>
<td>35</td>
<td>Skin inf</td>
<td>Culture positive for M. chelonae in four cases</td>
<td>Median incubation period 16 d; epidemiologically linked to two mesotherapy training courses; M. chelonae isolated from a procaine vial</td>
<td></td>
</tr>
<tr>
<td>Mesotherapy</td>
<td>2005</td>
<td>District of Columbia, USA</td>
<td>14</td>
<td>Skin inflam, ulceration, and drainage at sites of injection</td>
<td>Culture positive for M. chelonae in one case</td>
<td>All received injections from the same person at a private home; multiple breaches in safe injection practices reported</td>
<td></td>
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</tbody>
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Table 1 (continued)

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Year</th>
<th>Location</th>
<th>Number of patients with infective complications</th>
<th>Type(s) of infection</th>
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<tbody>
<tr>
<td>Mesotherapy</td>
<td>2006–2007</td>
<td>France</td>
<td>16</td>
<td>Skin infection</td>
<td><em>M. chelonae</em> and/or <em>Mycobacterium frederiksbergense</em></td>
<td>105 patients exposed, 48 responded and examined; incubation period 7–152 d; inappropriate cleansing of equipment with tap water; 100% similarity between patient isolates and tap water isolates of <em>M. chelonae</em> by PFGE</td>
<td>41</td>
</tr>
<tr>
<td>Mesotherapy</td>
<td>2006–2007</td>
<td>France</td>
<td>16</td>
<td>Skin infection</td>
<td>Culture positive in 12 cases: <em>M. chelonae</em> (11) and/or <em>M. frederiksbergense</em> (2)</td>
<td>All received mesotherapy from the same practitioner; incubation period 7–152 d; <em>M. chelonae</em> identified from tap water</td>
<td>42</td>
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<tr>
<td>Mesotherapy</td>
<td>2007</td>
<td>La Rioja, Spain</td>
<td>39</td>
<td>Skin infection</td>
<td>Culture positive for <em>M. fortuitum</em> in 12 cases</td>
<td>138 persons received mesotherapy by a single practitioner in the same salon; incubation period 1–254 d</td>
<td>43</td>
</tr>
<tr>
<td>Liposuction and other cosmetic surgeries</td>
<td>2003–2004</td>
<td>Eastern USA, ex Dominican Republic</td>
<td>20</td>
<td>Abdominal wall wound infections, breast implant infections</td>
<td><em>M. abscessus</em></td>
<td>Received breast augmentation and liposuction at a clinic in Dominican Republic; 45% of cases had procedures in the same clinic; incubation period 2–18 wk</td>
<td>44</td>
</tr>
</tbody>
</table>

NA = not available; PAAG = polyacrylamide hydrogel; PFGE = pulsed-field gel electrophoresis; TRAM = transverse rectus abdominis musculocutaneous.
Ear piercing, for example, may lead to infection and purulent discharge in 11–24% of the individuals (Fig. 1). The commonest pathogens involved are *S. aureus*, *Streptococcus pyogenes*, and *P. aeruginosa*. Local abscess formation, toxic shock syndrome, and Fournier’s gangrene (after genital piercing) have been reported to occur after piercing. Auricular chondritis caused by *P. aeruginosa* is particularly difficult to manage, and high piercing of the ear pinna is a definite risk factor for the development of infection. Failure to disinfect the equipment properly and use of contaminated disinfectants have been found to be associated with *P. aeruginosa* chondritis after high piercing. The cartilage is an avascular structure; its infection is extremely problematic because systemically administered antibiotics may not penetrate sufficiently well into the site of infection. Substantial necrosis and destruction of the cartilage can be followed by deformities that require extensive reconstructive surgery to correct. Infections caused by rapidly growing mycobacteria following body piercing have also been reported.

Intraoral piercing poses some unique infective problems. The oral mucosa is heavily colonized by normal flora, and therefore invasive infections such as intraoral abscesses and severe head and neck infections such as Lemierre’s syndrome can occur readily following oral piercing. Infective endocarditis is a major complication following piercing of the mouth and skin. Reported pathogens include *S. aureus*, coagulase-negative staphylococci, viridans streptococci, *S. pyogenes*, *Neisseria mucosa*, *Haemophilus aphrophilus*, *H. parainfluenzae*, and *Gemella*, all of which are part of the normal flora of the skin and oropharynx. Although current guidelines on antibiotic prophylaxis against infective endocarditis do not specifically address body piercing, this prophylaxis has been suggested to be beneficial for intraoral piercing. Nevertheless, the actual benefit of single doses of antibiotics can be nullified by the prolonged presence of mucosal wounds and foreign bodies in such settings.

**Breast augmentation procedures**

Breast implants are used for either reconstructive surgery or cosmetic purposes. The practice of injecting paraffin or silicone for this purpose is now obsolete because of the severe adverse reactions associated with it, such as mastitis, chronic inflammation (paraffinoma and siliconoma), and discharging sinuses (Fig. 2). Nowadays, either fixed-volume silicone gel-filled implants or adjustable-volume saline-filled implants are most commonly used. In some countries, soft tissue fillers such as polyacrylamide hydrogel have also been used in breast augmentation procedures. Infective complications of breast augmentation may be classified into early and late infections. An overall incidence of 2.5% is often quoted, with acute postoperative infection accounting for 1.7% and late infection for 0.8%. Infections that occurred after 1 month postoperatively are usually considered to be “late” infections. The risk of infection is much higher (up to 10 times) in patients undergoing reconstructive surgery as compared to those undergoing aesthetic surgery because the former group of patients have a higher incidence of underlying (systemic and local) comorbidities, prior chemotherapy and radiotherapy, and a greater degree of local tissue trauma. The use of human acellular dermal matrix for cosmetic breast augmentation is associated with a higher risk of infection (relative risk 2.47) and other complications as compared to conventional submuscular reconstructions.

The routes of infection for breast implants are similar to those for other implants such as joint prostheses and heart valves. Infection can result from the use of contaminated prostheses or saline (in the case of saline-filled implants), microbial contamination of the surgical site during surgery, or seeding from distant infective foci. On rare occasions, contaminated gentian violet skin-marking solution led to an outbreak of *Mycobacterium abscessus* surgical wound infection after cosmetic surgery.

The breast glandular tissues are not sterile, as the ducts are colonized by normal flora of the skin. Such microbes are the commonest cause of acute postoperative infections. *S. aureus* is the predominant pathogen, with beta-hemolytic streptococci and fast growing atypical mycobacteria being important causes as well. Late infections are often secondary to episodes of bacteremia and distant infections; cases due to *S. aureus*, coagulase-negative staphylococci, *P. aeruginosa*, *Pasteurella multocida*, *Bacteroides fragilis*, *Enterococcus*, and *Klebsiella pneumoniae* have been reported. The optimal pharmacological prophylaxis of breast implant infections is not completely clear, and current

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**Figure 1** Cellulitis around the earlobe after ear piercing.
practice varies greatly among different centers due to the lack of large randomized controlled trials. Local irrigation, using povidone-iodine, bacitracin, povidone-iodine/cefazolin/gentamicin, or bacitracin/cefazolin/gentamicin, has been performed. Preoperative prophylactic antibiotics are useful for preventing surgical site infection in patients undergoing breast surgery. The most commonly used antibiotics are penicillins with antistaphylococcal activities, first-generation cephalosporins, and beta-lactam/beta-lactamase inhibitor combinations; patients with beta-lactam allergy generally receive macrolides or clindamycin. The role of postoperative antibiotic prophylaxis in breast augmentation surgery is more contentious. In some studies, no benefits have been found after giving antibiotics for 3 postoperative days in primary or secondary breast augmentation, whereas other studies have advocated the use of more prolonged postoperative prophylaxis in breast reconstruction patients who required implants, especially in those who had received chemotherapy and/or radiotherapy after surgery.

Injectable permanent soft tissue fillers, such as polyacrylamide hydrogel, for breast augmentation was first used in Ukraine, subsequently gaining popularity in China. The polymer is considered to be nontoxic, nonbiodegradable, and nonteratogenic. Some claimed that tissue response to the polyacrylamide polymer is moderate to minimal with little fibrosis, but others reported dense fibrous tissue formation with inflammation. In contrast to the small amount being used in facial augmentation, large volumes (up to 200 mL or more) of polyacrylamide hydrogel are used in breast augmentation. Adverse reactions to polyacrylamide polymer following its use in breast augmentation were first observed in 1997. Since then a number of complications, such as multiple induration, palpable lumps, mastalgia, lactorrhea, disfigurement, migration of implant, and infection, were reported. Infection has been quoted in most series as a complication (incidence ranged from 4% to 27%), but its detailed course and causative agents were not described.

Mesotherapy, liposuction, tissue filler injections, and other procedures

Subcutaneous injection therapy, also known as mesotherapy, using phosphatidylcholine or other agents (such as isoproterenol), has become a popular method for body contouring in some countries, although the efficacy of such procedures has not been confirmed scientifically. By far, the commonest pathogens causing infections after mesotherapy are atypical mycobacteria, especially the rapid growers such as \textit{M. chelonae} and \textit{M. abscessus}, and outbreaks are being reported regularly. The use of contaminated injection materials and tap water for cleaning instruments has been associated with outbreaks of infection. Similarly, the rapid growers are often involved in infections associated with liposuction. Indeed, a number of novel \textit{Mycobacterium} species have been described in recent years in cases of infections acquired after body modification or cosmetic procedures, such as \textit{M. cosmeticum}, \textit{M. jacuzzii}, \textit{M. massiliense}, and \textit{M. bolletii}. In addition, other environmental pathogens such as \textit{Nocardia} and \textit{Sporothrix schenckii} are associated with such procedures. It is therefore necessary to take precautions to prevent the spread of these organisms during injection therapy.
imperative that patients who have developed infection after body modifications should be investigated for such mycobacterial, nocardial, and fungal etiologies, in addition to routine bacteriological studies.

In recent years, the use of dermal filler injections for soft tissue (especially facial) augmentation has gained popularity in many parts of the world. Although the procedure is generally safe, associated infective complications are not unheard of.\textsuperscript{112–114} Chronic mandibular osteomyelitis has been reported to complicate facial augmentation using polyacrylamide hydrogel.\textsuperscript{115} Unlike in other conventional prosthesis-related infections, complete removal of the injected fillers may not be possible, and hence a more prolonged course of antibiotics may be necessary in some situations.

More recently, new procedures have been used in some developed countries for their purported cosmetic or health benefits. One example is the so-called “cell therapy”, which involves the injection of cells of animal or human origin or extracts of animal tissues. In addition to the lack of any scientific basis for their therapeutic claims, the potential health risks of such “therapies” are unknown. Transmission of zoonotic pathogens is one theoretical possibility, but a real threat is the transmission of bacterial pathogens through contaminations during the procedure. In a recent outbreak in Hong Kong, at least four customers who had received “cytokine-induced killer cell therapy” (intravenous infusion of the customers’ own leukocytes after a period of \textit{ex vivo} incubation) at a beauty treatment center developed severe septic shock caused by \textit{M. abscessus}.\textsuperscript{116} At least one patient died as a result of the infection. Although the exact mode of contamination remains to be investigated at the time of writing, this incident highlights the importance of stricter public health control on these potentially dangerous procedures.

\textbf{General approach to diagnosis and therapy}

The presentation of body modification-related infections falls into three major categories: infections caused by bloodborne pathogens (mainly viruses such as HBV, HCV, and HIV); local infections at the sites of tattoo, piercing, surgery, or injections; and metastatic or disseminated infections. Patients who had received body modifications should alert the clinician to these associated infections. Conversely, in patients with aforementioned infections but with unexplained origins, body modification procedures should be enquired as possible predisposing factors. This is not only clinically important for the individual patients, but also significant from the public health perspective. Initial cases may represent the few most severe victims, and further investigations and case findings may unravel a silent outbreak in the community. Prompt control measures by the health authorities are crucial to prevent the occurrence of new cases.

The clinical diagnosis of local or systemic infections is generally not difficult for most clinicians. The timing and nature of specific microbiological investigations are crucial for more serious cases. In otherwise uncomplicated infections, such as cellulitis or local abscesses, patients are frequently managed in the primary health-care setting with empirical antibiotics and/or drainage, often without microbial cultures. First-line empirical antibiotics with beta-lactam/beta-lactamase inhibitor combinations (such as co-amoxiclav or ampicillin–sulbactam) or first- and second-generation cephalosporins (such as cephalixin, cefazolin, or cefuroxime) should cover the common commensal flora, including staphylococci, beta-hemolytic streptococci, and some Enterobacteriaceae (especially in the case of genital piercing). Infections in the oral cavity or pelvic regions, or specific syndromes such as Lemierre’s syndrome should be treated with antibiotics with anaerobic coverage (beta-lactam/beta-lactamase inhibitor combinations or adding metronidazole to the cephalosporin regimen). Severe or systemic infections or those that do not respond to standard treatments should always be accompanied by appropriate microbiological investigations. This is important not only for the diagnosis of fungal, nocardial, and mycobacterial pathogens, but also for excluding antibiotic-resistant pathogens such as \textit{P. aeruginosa} and community-associated methicillin-resistant \textit{S. aureus} that is prevalent in many parts of the world.

Acid-fast staining, and mycobacterial and fungal cultures should be performed in nonresponding cases. Pus specimens or skin biopsies should be performed in patients presenting with nodular or pustular lesions suggestive of atypical mycobacterial infections. Additionally, histological examination of the biopsy samples is needed since some fungal or mycobacterial pathogens may require prolonged incubation for growth or may not be readily cultivable in routine culture media. The presence of these microbes and the type of inflammatory response may help establish the preliminary diagnosis and guide empirical therapy.

Patients with suspected breast implant infections should undergo ultrasonographic or computed tomography examination, and any collection should be aspirated for microbiological investigations, including Gram and acid-fast stain, and routine bacterial and mycobacterial cultures. Surgical removal of the implant should ideally be performed, and a 2-week course of antibiotic has to be advocated.\textsuperscript{88} Antibiotics such as co-amoxiclav, ampicillin–sulbactam, or a first- or second-generation cephalosporin will cover most of the common pathogens, while antibiotics with antipseudomonal activities should be used for patients with documented \textit{P. aeruginosa} infection. Immediate reimplantation is not advisable.

\textbf{Prevention and regulation}

Preventive measures can reduce but not abrogate all the risks of infection associated with body modification. Infections by endogenous flora of the skin and mucosae after body piercing cannot be prevented completely, given that the wounds take a long time to heal and that foreign bodies are present. Prevention of exogenous infections requires proper skin antisepsis prior to the procedures, adequate disinfection of all instruments and the operating field, hand hygiene, use of standard precautions, avoiding the presence of pet animals and plants in the premises, and proper choice and maintenance of antiseptics, disinfectants, and sterilization techniques. Improper choices, dilutions, and topping up of chemical disinfectants as well
as their use beyond the expiry dates constitute a recipe for disaster. Contamination of disinfectants by environmental bacteria is well documented, and such incidents can lead to outbreaks of infections.\textsuperscript{41,42} \textit{P. aeruginosa} is a frequent culprit, although bacteria such as other \textit{Pseudomonas} spp., \textit{B. kholderia} spp. (especially \textit{B. cepacia}), \textit{Serratia marcescens}, and atypical mycobacteria can also be involved.\textsuperscript{41} Atypical mycobacteria can often be found in tap water, and the sole use of tap water for cleaning of mesotherapy instruments has been reported to lead to the outbreaks of cutaneous mycobacterial infections.\textsuperscript{41,42}

In many developed countries, guidelines or codes of practice are available for body art practitioners and parlors to reduce the risk of transmission of infection.\textsuperscript{118–121} However, these regulations are not always legally binding. Body modification practitioners and tattooists likewise have been found to have inadequate training, insufficient knowledge of infection control, and poor compliance to proper safety precautions.\textsuperscript{121–124} Activities such as more stringent inspections, providing adequate educating, and more feedback activities have to be carried out by the regulatory authorities in this often-overlooked field to minimize the risk of infection and other health problems.\textsuperscript{124,126}

**Conclusion**

Body modification is a popular form of body art in many parts of the world. Various patient- and procedure-related factors may predispose individuals to the development of local and systemic infections. Individuals must be made aware of the health risks prior to undergoing any such procedure, and medical practitioners should be aware of the infective and noninfective complications associated with these procedures. Patients with infections not responding to conventional antibacterial coverage should be investigated for pathogens such as atypical mycobacteria, nocardiae, and fungi. More importantly, lapses in infection control and disinfection procedures have frequently been found to result in outbreaks of infections. Stricter regulations and inspections of operators by the health authorities are necessary to reduce the risks, and the medical practitioners, who play an important role in the surveillance of disease activity, should have a high index of suspicion for identifying such outbreaks, especially when outbreak-associated pathogens such as atypical mycobacteria or pseudomonads are isolated.

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