Antibiotic Susceptibility of *Staphylococcus aureus* in Atopic Dermatitis: Current Prevalence of Methicillin-Resistant *Staphylococcus aureus* in Korea and Treatment Strategies

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**Background:** *Staphylococcus aureus* is a well-known microbe that colonizes or infects the skin in atopic dermatitis (AD). The prevalence of methicillin-resistant *S. aureus* (MRSA) in AD has recently been increasing. **Objective:** This study aimed to determine the antimicrobial susceptibility patterns in AD skin lesions and evaluate the prevalence of MRSA in Korea. We also recommend proper first-line topical antibiotics for Korean patients with AD. **Methods:** We studied *S. aureus*-positive skin swabs (n = 583) from the lesional skin of infants, children, and adults who presented to our outpatient clinic with AD from July 2009 to April 2012. **Results:** *S. aureus* exhibited high susceptibility against most antimicrobial agents. However, it exhibited less susceptibility to benzylpenicillin, erythromycin, clindamycin, and fusidic acid. The prevalence of MRSA was 12.9% among 583 *S. aureus* isolates, and the susceptibility to oxacillin was significantly lower in infants in both acute and chronic AD lesions. **Conclusion:** *S. aureus* from AD has a high prevalence of MRSA and multidrug resistance, especially in infants. The rate of fusidic acid resistance is high among all age groups, and mupirocin resistance increases with age group regardless of lesional status. This is the first study comparing the antimicrobial susceptibility rates of *S. aureus* isolates from AD cases with respect to age and lesion status in Korea. (**Ann Dermatol** 27(4) 398~403, 2015)

**Keywords:** Atopic dermatitis, Antimicrobial susceptibility, Methicillin-resistant *Staphylococcus aureus*, *Staphylococcus aureus*

**INTRODUCTION**

Atopic dermatitis (AD) is a common chronic inflammatory skin disorder that induces several symptoms including pruritus, dryness, and secondary cutaneous infection. The skin lesions of patients with AD are classified as acute or chronic according to the skin’s condition and cytokine expression level in the lesional skin. Both types of atopic lesions often impair skin barrier function and exhibit decreased antimicrobial peptides expression and defective innate immune activity. Accordingly, patients with AD are more susceptible to colonization with bacteria, especially *Staphylococcus aureus*. *S. aureus* is a well-known organism that colonizes and infects the skin in AD. The prevalence of skin colonization with *S. aureus* is much higher in patients with AD than that in healthy individuals: 75% ~ 100% of patients with AD exhibit *S. aureus* colonization on their lesional skin, while the bacterium is isolated from only 5% ~ 30% of individuals without AD. Among *S. aureus* strains, methicillin-resistant *S. aureus* (MRSA) is one of the most important pathogens of community-acquired infections in many countries. Since MRSA was first reported in 1968 by Barrett et al., the prevalence of MRSA has increased gradually, especially in recent years. Growing evidence sug-
gests the skin of patients with AD may be a preferred reservoir for this pathogen. Topical antimicrobial agents are cost-effective therapies for cutaneous bacterial infections. Several approved topical agents are used to treat skin infections, many of which are usually prescribed if bacterial skin infection is suspected in AD. Among them, mupirocin and fusidic acid are the most commonly used to treat cutaneous infection. However, the percentage of isolates resistant to these topical antibiotics has been increasing.

As antibiotic therapy plays an important role in treating bacterial skin infections in AD, the present study evaluated the antimicrobial susceptibility of S. aureus in patients with AD and determined the prevalence of resistant strains, especially MRSA. We also determined whether there are differences in the resistance rates with respect to age, because previous studies show that MRSA is more prevalent in children than in adults. Furthermore, we determined the prevalence of resistance rates with respect to the duration of skin lesions to provide helpful information regarding the proper selection of topical antibiotics according to lesional status in AD. The results also provide information about the current prevalence of MRSA in Korea.

**MATERIALS AND METHODS**

The study protocol was approved by the Samsung Medical Center institutional review board (2002-10-009) and conducted in accordance with the Declaration of Helsinki. Written informed consent was obtained from all patients or their guardians.

**Patients**

We retrospectively collected data from patients with AD who were positive for S. aureus on a skin swab performed during their first visit. A total of 583 patients including 90 infants, 187 children, and 306 adults (135 acute and 448 chronic skin lesions) who visited our dermatology outpatient clinic from July 2009 to April 2012 were recruited (Fig. 1). The exclusion criteria included the presence of impetigo, cellulitis, or fungal infection; and the presence of other inflammatory cutaneous disorder such as psoriasis, seborrheic dermatitis, and pityriasis rosea. No patients had a history of any treatment including antibiotics in the preceding weeks. We classified AD skin lesions as acute or chronic lesions; acute lesions were defined as erythematous eczematous skin lesions with oozing and crust, while chronic lesions included erythematous to brownish papules and lichenification with xerosis.

**Isolation and identification of S. aureus from AD lesions**

Skin swabs for culture were taken from the lesions (i.e., oozing sites in patients with acute skin lesions or the antecubital fossa in patients with intact skin) using sterile cotton tips (BBL CultureSwab Plus; Sparks, MD, USA). Samples were inoculated onto blood agar plates, and S. aureus isolates were identified by a coagulase slide test and catalase reaction.

**Antimicrobial susceptibility**

The antimicrobial susceptibility of each isolate was determined by the VITEK 2 system using the AST-P601 card panel (Biomerieux, Lyon, France). The tested antibiotics included benzylpenicillin, oxacillin, gentamicin, habekacin, ciprofloxacin, telithromycin, tigecycline, erythromycin, clindamycin, quinupristin/dalfopristin, linezolid, teicoplanin, vancomycin, tetracycline, nitrofurantoin, fusidic acid, rifampicin, trimethoprim/sulfamethoxazole, and mupirocin.

**Statistical analysis**

Statistical significance was analyzed by the $\chi^2$ test or Fisher’s exact test with a Bonferroni correction where appropriate. Logistic regression analysis was used for multivariate analysis. The level of significance was set at $p < 0.05$. Statistical analyses were performed by using SAS version 9.4 software (SAS Institute, Cary, NC, USA).

**RESULTS**

**Antimicrobial susceptibility patterns of S. aureus in patients with AD**

Most S. aureus isolates exhibited high susceptibility to most antimicrobial agents. The isolates exhibited less susceptibility to benzylpenicillin, erythromycin, clindamycin,
and fusidic acid. In particular, isolates from chronic skin lesions showed low susceptibility to oxacillin. Among the tested antibacterial agents, *S. aureus* showed the highest resistance rate to benzylpenicillin followed by fusidic acid. There were no significant differences in susceptibility between acute and chronic skin lesions (Fig. 2).

**Antimicrobial susceptibility of *S. aureus* in acute AD lesions**

In acute cutaneous lesions, *S. aureus* had the lowest susceptibility to benzylpenicillin. These isolates also exhibited low susceptibility to erythromycin, clindamycin, and fusidic acid. However, all *S. aureus* isolates were susceptible to vancomycin, habekacin, tigecycline, quinupristin/dalfopristin, linezolid, teicoplanin, and trimethoprim/sulfamethoxazole.

Regarding the susceptibility rates among age groups, susceptibility to oxacillin was significantly lower in the infant group (77.78% vs. 96.43% vs. 93.75% in the infant, child, and adult samples, respectively, *p* < 0.0001). There were no significant differences in the susceptibility rates to other antimicrobial agents with respect to age group (Table 1).

**Antimicrobial susceptibility of *S. aureus* in chronic AD lesions**

Similar to the results in patients with acute AD lesions, *S. aureus* from chronic lesions exhibited the lowest susceptibility to benzylpenicillin followed by fusidic acid, erythromycin, clindamycin, and oxacillin. Meanwhile, *S. aureus* exhibit 100% susceptibility to habekacin, linezolid, teicoplanin, vancomycin, and rifampicin.

The antimicrobial susceptibility to oxacillin was sig-

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**Table 1.** Comparison of antimicrobial susceptibility of acute lesions between age groups

| Drug                          | Infant | Susceptibility in acute lesion | Child | Adult | p-value |
|-------------------------------|--------|--------------------------------|-------|-------|---------|
|                               |        |                                |       |       |         |
| Benzylpenicillin              | 2/27 (7.41) | 2/28 (7.14) | 11/80 (13.75) | 1.0  |
| Oxacillin                     | 21/27 (77.78) | 27/28 (96.43) | 75/80 (93.75) | <0.0001 |
| Gentamicin                    | 26/27 (96.30) | 24/28 (85.71) | 68/80 (85.00) | 0.72  |
| Habekacin                     | 27/27 (100) | 28/28 (100) | 80/80 (100) | 1.0  |
| Ciprofloxacin                 | 26/27 (96.30) | 27/28 (96.43) | 79/80 (98.75) | 0.72  |
| Telithromycin                 | 27/27 (100) | 28/28 (100) | 79/80 (98.75) | 1.0  |
| Tigecycline                   | 27/27 (100) | 28/28 (100) | 80/80 (100) | 1.0  |
| Erythromycin                  | 20/27 (74.07) | 24/28 (85.71) | 71/80 (88.75) | 0.40  |
| Clindamycin                   | 20/27 (74.07) | 24/28 (85.71) | 74/80 (92.50) | 0.09  |
| Quinupristin/dalfopristin     | 27/27 (100) | 28/28 (100) | 80/80 (100) | 1.0  |
| Linezolid                     | 27/27 (100) | 28/28 (100) | 80/80 (100) | 1.0  |
| Teicoplanin                   | 27/27 (100) | 28/28 (100) | 80/80 (100) | 1.0  |
| Vancomycin                    | 27/27 (100) | 28/28 (100) | 80/80 (100) | 1.0  |
| Tetracycline                  | 24/27 (88.89) | 27/28 (96.43) | 77/80 (96.25) | 0.52  |
| Nitrofurantoin                | 27/27 (100) | 28/28 (100) | 78/80 (97.50) | 1.0  |
| Fusidic acid                  | 22/27 (81.48) | 21/28 (75.00) | 52/80 (65.00) | 0.44  |
| Rifampicin                    | 27/27 (100) | 28/28 (100) | 79/80 (98.75) | 1.0  |
| Trimethoprim/sulfamethoxazole | 27/27 (100) | 28/28 (100) | 80/80 (100) | 1.0  |
| Mupirocin                     | 25/27 (92.59) | 21/23 (91.30) | 63/71 (88.73) | 1.0  |

Values are presented as number (%).
Table 2. Comparison of antimicrobial susceptibility of chronic lesions between age groups

| Drug                  | Infant | Child                  | Adult                  | p-value |
|-----------------------|--------|------------------------|------------------------|---------|
| Benzylpenicillin      | 9/63 (14.29) | 19/159 (11.95)     | 53/226 (23.45)       | 0.02    |
| Oxacillin             | 42/63 (66.67) | 135/159 (84.91)    | 208/226 (92.04)      | <0.0001 |
| Gentamicin            | 58/63 (92.06) | 150/159 (94.34)    | 204/226 (90.27)      | 0.70    |
| Habekacin             | 63/63 (100) | 159/159 (100)       | 226/226 (100)        | 1.0     |
| Ciprofloxacin         | 62/63 (98.41) | 159/159 (100)      | 223/226 (98.67)      | 0.54    |
| Telithromycin         | 62/63 (98.41) | 157/159 (98.74)    | 221/226 (97.79)      | 1.0     |
| Tigecycline           | 62/63 (98.41) | 159/159 (100)      | 226/226 (100)        | 0.28    |
| Erythromycin          | 48/63 (76.19) | 129/159 (81.13)    | 203/226 (89.82)      | 0.01    |
| Clindamycin           | 50/63 (79.37) | 130/159 (81.76)    | 206/226 (91.15)      | 0.01    |
| Quinupristin/dalfopristin | 63/63 (100) | 158/159 (99.37)   | 226/226 (100)        | 0.99    |
| Linezolid             | 63/63 (100) | 159/159 (100)      | 226/226 (100)        | 1.0     |
| Teicoplanin           | 63/63 (100) | 159/159 (100)      | 226/226 (100)        | 1.0     |
| Vancomycin            | 63/63 (100) | 159/159 (100)      | 226/226 (100)        | 1.0     |
| Tetracycline          | 57/63 (90.48) | 158/159 (99.37)    | 217/226 (96.02)      | 0.01    |
| Nitrofurantoin        | 61/63 (96.83) | 157/159 (98.74)    | 224/226 (99.12)      | 0.60    |
| Fusidic acid          | 54/63 (85.71) | 122/259 (76.73)    | 157/226 (69.47)      | 0.04    |
| Rifampicin            | 63/63 (100) | 159/159 (100)      | 226/226 (100)        | 1.0     |
| Trimethoprim/sulfamethoxazole | 63/63 (100) | 159/159 (100)     | 224/226 (99.12)      | 1.0     |
| Mupirocin             | 58/60 (91.68) | 131/139 (94.24)    | 196/209 (93.78)      | 1.0     |

Values are presented as number (%).

Table 3. Methicillin-resistant *Staphylococcus aureus* isolation rates in all atopic dermatitis cases

| Source        | Methicillin-resistant | Methicillin-sensitive | Total |
|---------------|-----------------------|-----------------------|-------|
| Acute lesion  |                        |                       |       |
| Infant        | 6 (22.2)               | 21 (77.8)             | 27    |
| Child         | 1 (3.6)                | 27 (96.4)             | 28    |
| Adult         | 5 (6.3)                | 75 (93.7)             | 80    |
| Chronic lesion|                        |                       |       |
| Infant        | 21 (33.3)              | 42 (66.7)             | 63    |
| Child         | 24 (15.1)              | 135 (84.9)            | 159   |
| Adult         | 18 (8.0)               | 208 (92.0)            | 226   |
| Total         | 75 (12.9)              | 508 (87.1)            | 583   |

Values are presented as number (%) or number only.

Significantly lower in the infant group than the child and adult groups (p < 0.0001). There were other significant differences in the antimicrobial susceptibility among the three age groups: benzylpenicillin (p = 0.02), erythromycin (p = 0.01), clindamycin (p = 0.01), tetracycline (p = 0.01), fusidic acid (p = 0.04). The *S. aureus* isolates from the infant group were less susceptible to these antibiotics, except fusidic acid, which showed a lower susceptibility rate in the adult group (Table 2).

**Isolation rates of MRSA in AD**

Among the 583 *S. aureus* isolates, 75 (12.9%) were MRSA. The isolation rate of MRSA was significantly higher in infants with AD than that of adults or children with AD in both acute and chronic cutaneous lesions (Table 3).

**Treatment response to oral antibiotics in the acute MRSA group**

Among the 12 AD cases with acute skin lesions colonized with MRSA, 7 patients (4 infants, 1 child, and 2 adults) were treated with oral antimicrobial agents because of severe oozing over a large body surface area. Three patients were treated with a first-generation cephalosporin (i.e., cephradine) for two weeks, and four were treated with a second- or third-generation cephalosporin (i.e., cefuroxime and cefpodoxime). All patients taking oral cephalosporin antibiotics showed improvement of subjective symptoms and good recovery of cutaneous lesions.

**DISCUSSION**

MRSA (i.e., oxacillin resistant) is a major pathogen in many infectious diseases. MRSA was historically considered an important healthcare-acquired pathogen but has recently been regarded as a major cause of infection in normal populations without healthcare-associated risk factors such as long-term admission periods and intensive care unit stay. So called "community-associated MRSA"
(CA-MRSA) strains are some of the most common pathogens found in skin and soft tissue infections in many countries\(^1\). One study reports the prevalence of CA-MRSA ranged from 15% to 75% among adults in 11 university-affiliated emergency departments throughout the United States\(^1\). MRSA strains account for 36%, 30%, and 23% of staphylococcal skin and soft tissue infections in North America, Latin America, and Europe, respectively\(^1\). Regarding patients with AD, several studies have investigated the incidence of MRSA isolated from AD skin lesions\(^13\). Hoeger\(^14\) did not identify MRSA from patients with AD in a pediatric outpatient population in 2004. However, in New Zealand, 2% of *S. aureus* isolates from pediatric AD cases were MRSA\(^15\). In addition, Niebuhr et al.\(^15\) found MRSA in 3% of *S. aureus* isolates in patients with AD. Up to 30% of *S. aureus* isolates from AD cases were reported to be MRSA in a Taiwanese study population in 2011\(^16\). Eczematous lesions in AD are known to be a source of transmission of *S. aureus*. The increasing incidence rates of CA-MRSA in skin and soft tissue infections raise concerns that AD skin is a favorable reservoir for this drug-resistant organism. According to one study of the epidemiological characteristics of MRSA in Korea, 18.3% of *S. aureus* isolates in children with AD lesions were MRSA\(^17\).

In the present study, 12.9% (75/583) of *S. aureus* isolates were MRSA. MRSA was found in both acute and chronic AD lesions but more so in chronic cutaneous lesions. MRSA colonization rates are generally higher in acute skin lesions than chronic skin lesions. Our previous study of the colonization rate in AD also shows a higher *S. aureus* colonization rate (74%) in acute skin lesions than chronic skin lesions (38%)\(^18\). However, a large percentage of chronic AD skin lesions were colonized with MRSA (8.9% in acute lesions vs. 14.1% in chronic lesions, \(p > 0.05\)). This might be explained by a history of repetitive topical antibiotic administration in chronic AD.

Interestingly, in the present study, the prevalence of MRSA was higher in the infant group regardless of lesional status. In one study, almost half of MRSA-positive children were <5 years old, and children aged between 1 month and 2 years represented just over one-third of all MRSA-positive cases\(^19\). However, it is unknown why the resistance rate is higher in infants than other age groups. Therefore, the molecular characteristics of MRSA strains by genotyping must be evaluated further to better understand about the resistance rate in infants.

The topical use of antimicrobial agents for the treatment of AD skin lesions is common and has advantages over systemic therapy with respect to cost-effectiveness and the absence of severe systemic side effects. However, the frequent use of topical antibiotics promotes the development of resistant strains. Fusidic acid is one of the most commonly used topical antibiotics in dermatology worldwide. Many studies report resistance rates against fusidic acid have increased\(^20\)-\(^24\). Accordingly, in the present study, *S. aureus* showed low susceptibility rates to fusidic acid in both acute and chronic lesions. In chronic AD skin lesions in particular, resistance rates to fusidic acid increased significantly with age (\(p = 0.04\)). Inappropriate use of topical antibiotics leading to resistance may threaten the efficacy of systemic antibiotics for the treatment of serious *S. aureus* infections such as osteomyelitis and severe surgical wound infections. Therefore, the topical use of fusidic acid for empirical treatment must be restricted.

Topical mupirocin has been used since 1994 in Korea, and its use has been increasing dramatically since\(^5\). Yun et al.\(^24\) first detected mupirocin-resistant *S. aureus* in Korea, with a prevalence of 5%. Up to 25.3% of *S. aureus* isolates exhibit resistance to mupirocin in certain intensive care unit settings\(^5\). In the present study, antimicrobial susceptibility to mupirocin was relatively lower in the adult group than the infant or child group regardless of the chronicity of the lesions. The frequent and repeated use of topical mupirocin in recent years may have influenced these outcomes. Thus, awareness and research about mupirocin resistance should be bolstered for the proper long-term management of AD skin lesions.

We treated 7 MRSA-positive patients with oral cephalosporin with good subjective and objective results, suggesting CA-MRSA can be controlled easily with oral cephalosporin antibiotics.

In conclusion, the prevalence of MRSA was higher in infants with AD than children and adults with AD regardless of lesional status. Furthermore, the results indicate it is rational to administer topical antibiotics susceptible to MRSA as first-line treatment for infants with AD. In addition, fusidic acid resistance was high in all age groups, and resistance rates against mupirocin tended to increase with age regardless of lesional status. This is the first study comparing the antimicrobial susceptibility rates of *S. aureus* isolates from AD patients of different age groups and lesional status in Korea. Thus, this study provides useful information for selecting a proper topical antimicrobial agent for patient-specific treatment according to their age and lesional status.

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REFERENCES

1. Breuer K, HAUSSLER S, KAPP A, Werfel T. Staphylococcus aureus: colonizing features and influence of an antibacterial treatment in adults with atopic dermatitis. Br J Dermatol 2002;147:55-61.

2. Gong JQ, Lin L, Lin T, Hao F, Zeng FQ, Bi ZG, et al. Skin colonization by Staphylococcus aureus in patients with eczema and atopic dermatitis and relevant combined topical therapy: a double-blind multicentre randomized controlled trial. Br J Dermatol 2006;155:680-687.

3. Higaki S, Morohashi M, Yamagishi T, Hasegawa Y. Comparative study of staphylococci from the skin of atopic dermatitis patients and from healthy subjects. Int J Dermatol 1999;38:265-269.

4. Barrett FF, McGehee RF Jr, Finland M. Methicillin-resistant Staphylococcus aureus at Boston City Hospital. Bacteriologic and epidemiologic observations. N Engl J Med 1968;279:441-448.

5. Park SY, Kim SM, Park SD. The prevalence, genotype and antimicrobial susceptibility of high- and low-level mupirocin resistant methicillin-resistant Staphylococcus aureus. Ann Dermatol 2012;24:32-38.

6. Dukic VM, Lauderdale DS, Wilder J, Daum RS, David MZ. Epidemiology of community-associated methicillin-resistant Staphylococcus aureus in the United States: a meta-analysis. PLoS One 2013;8:e52722.

7. Bratu S, Landman D, Gupta J, Trehan M, Panwar M, Quale J. A population-based study examining the emergence of community-associated methicillin-resistant Staphylococcus aureus USA300 in New York City. Ann Clin Microbiol Antimicrob 2006;5:29.

8. Popovich KJ, Hota B, ArouCheva A, Kurien L, Patel J, Lyles-Banks R, et al. Community-associated methicillin-resistant Staphylococcus aureus colonization burden in HIV-infected patients. Clin Infect Dis 2013;56:1067-1074.

9. Calfee DP. Methicillin-resistant Staphylococcus aureus and vancomycin-resistant enterococci, and other Gram-positives in healthcare. Curr Opin Infect Dis 2012;25:385-394.

10. Mediavilla JR, Chen L, Mathema B, Kreiswirth BN. Global epidemiology of community-associated methicillin resistant Staphylococcus aureus (CA-MRSA). Curr Opin Microbiol 2012;15:588-595.

11. Moran GJ, Krishnasadan A, Gorwitz RJ, Fosheim GE, McDougal UK, Carey RB, et al; EMERGency ID Net Study Group. Methicillin-resistant S. aureus infections among patients in the emergency department. N Engl J Med 2006;355:666-674.

12. Moet GJ, Jones RN, Biedenbach DJ, Stilwell MG, Fritsche TR. Contemporary RNs of skin and soft tissue infections in North America, Latin America, and Europe: report from the SENTRY Antimicrobial Surveillance Program (1998-2004). Diagn Microbiol Infect Dis 2007;57:7-13.

13. Hill SE, Yung A, Rademaker M. Prevalence of Staphylococcus aureus and antibiotic resistance in children with atopic dermatitis: a New Zealand experience. Australas J Dermatol 2011;52:27-31.

14. Hoeger PH. Antimicrobial susceptibility of skin-colonizing S. aureus strains in children with atopic dermatitis. Pediatr Allergy Immunol 2004;15:474-477.

15. Niebuhr M, Mai U, Kapp A, Werfel T. Antibiotic treatment of cutaneous infections with Staphylococcus aureus in patients with atopic dermatitis: current antimicrobial resistance and susceptibilities. Exp Dermatol 2008;17:953-957.

16. Tang CS, Wang CC, Huang CF, Chen SJ, Tseng MH, Lo WT. Antimicrobial susceptibility of Staphylococcus aureus in children with atopic dermatitis. Pediatr Int 2011;53:363-367.

17. Chung Hj, Jeon HS, Sung H, Kim MN, Hong SJ. Epidemiological characteristics of methicillin-resistant Staphylococcus aureus isolates from children with eczematous atopic dermatitis lesions. J Clin Microbiol 2013;46:991-995.

18. Park HY, Kim CR, Huh IS, Jung MY, Seo EY, Park JH, et al. Staphylococcus aureus colonization in acute and chronic skin lesions of patients with atopic dermatitis. Ann Dermatol 2013;25:410-416.

19. Mathow A, Forgirse S, Pelude L, Embree J, Gravel D, Langlemy JM, et al; Canadian Nosocomial Infection Surveillance Program. National surveillance of methicillin-resistant Staphylococcus aureus among hospitalized pediatric patients in Canadian acute care facilities, 1995-2007. Pediatr Infect Dis J 2012;31:814-820.

20. Shah M, Mohanraj M. High levels of fusidic acid-resistant Staphylococcus aureus in dermatology patients. Br J Dermatol 2003;148:1018-1020.

21. Ravenscroft JC, Layton A, Barham M. Observations on high levels of fusidic acid resistant Staphylococcus aureus in Harrogate, North Yorkshire, UK. Clin Exp Dermatol 2000;25:327-330.

22. Andersen BM, Bergh K, Steinbakk M, Syversen G, Magnaes B, Dalen H, et al. A Norwegian nosocomial outbreak of methicillin-resistant Staphylococcus aureus resistant to fusidic acid and susceptible to other antistaphylococcal agents. J Hosp Infect 1999;41:123-132.

23. Brown EM, Thomas P. Fusidic acid resistance in Staphylococcus aureus isolates. Lancet 2002;359:803.

24. Yun HJ, Lee SW, Yoon GM, Kim SY, Choi S, Lee YS, et al. Prevalence and mechanisms of low- and high-level mupirocin resistance in staphylococci isolated from a Korean hospital. J Antimicrob Chemother 2003;51:619-623.