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High Prevalence of Fluoroquinolone- and Methicillin-Resistant *Staphylococcus pseudintermedius* Isolates from Canine Pyoderma and Otitis Externa in Veterinary Teaching Hospital

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Recently, a total of 74 *Staphylococcus pseudintermedius* isolates were collected from clinical cases of canine pyoderma and otitis externa in Korea. In this study, we examined *in vitro* fluoroquinolone resistance among those isolates using a standard disc diffusion technique. The results demonstrated that, except for one isolate, approximately 18.9% to 27.0% of the isolates possessed bacterial resistance to both veterinary- and human-licensed fluoroquinolones including moxifloxacin (18.9% resistance), levofloxacin (20.3% resistance), ofloxacin (24.3% resistance), ciprofloxacin (25.7% resistance), and enrofloxacin (27.0% resistance). Most surprisingly, 14 out of 74 (18.9%) isolates were resistant to all the five fluoroquinolones evaluated. Moreover, a PCR detection of the methicillin resistance gene (*mecA*) among the 74 isolates revealed that 13 out of 25 (52.0%) *mecA*-positive isolates, but only 7 out of 49 (14.3%) *mecA*-negative isolates, were resistant to one or more fluoroquinones. Taken together, our results imply that bacterial resistance to both veterinary- and human-use fluoroquinolones becomes prevalent among the *S. pseudintermedius* isolates from canine pyoderma and otitis externa in Korea, as well as that the high prevalence of the *mecA*-positive *S. pseudintermedius* isolates carrying multiple fluoroquinolones resistance could be a potential public health problem.

Keywords: *Staphylococcus pseudintermedius*, fluoroquinolone, antibiotic resistance, dogs, *mecA* gene, prevalence

Staphylococcus pseudintermedius is an opportunistic bacterial pathogen that causes various dermatological diseases in dogs, and is known to be responsible for approximately 80% of canine pyoderma cases worldwide [21]. The microorganism has been differentiated from *S. intermedius* by a recent genotypic reclassification [5]. Interestingly, the first case of human infection by this microorganism [26] as well as the emergence and prevalence of methicillin-resistant populations [23] have been reported, implying potential cross-transmission between pet animals and humans.

Fluoroquinolone is a class of antimicrobials that are effective against a broad range of Gram-positive and -negative bacteria and, therefore, has been commonly used in humans and animals as antimicrobial therapeutics. The efficacy of fluoroquinolone in veterinary fields against the *S. intermedius* infection has been approved. For example, fluoroquinolones are recommended as a primary antibiotic regimen for canine pyoderma caused by *S. intermedius* [9]. However, gradual increases of fluoroquinolone resistance have been reported in *S. intermedius* isolates from canine pyoderma, otitis externa [10, 11, 15], and urinary tract infections [4], which might be due to extensive administration, unnecessary overdose, and/or prolonged misuse of fluoroquinolones [10, 22]. Several fluoroquinolones including enrofloxacin, difloxacin, orbifloxacin, and marbofloxacin are licensed for veterinary use [9]. Although ciprofloxacin and ofloxacin have been licensed for veterinary use in Korea, it is known that their use has been restricted to humans in many countries including the United States. Moreover, human-use fluoroquinolones such as levofloxacin and moxifloxacin are not recommended for animals. However, their chemical and structural similarities with veterinary-use fluoroquinolones may induce simultaneous resistance to both veterinary- and human-use fluoroquinolones.

In this study, we examined bacterial resistance of the 74 *S. pseudintermedius* isolates from canine pyoderma or otitis externa in Korea against the five fluoroquinolones;

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one veterinary-licensed fluoroquinolone (enrofloxacin) and the other four human-licensed ones (ciprofloxacin, ofloxacin, levofloxacin, and moxifloxacin). In addition, fluoroquinolone resistance among the methicillin-resistant *S. pseudintermedius* isolates was investigated by the detection of the methicillin resistance gene (*mecA*) by polymerase chain reaction (PCR).

Materials and Methods

Isolation and Identification of *S. pseudintermedius*

A total of 74 *S. pseudintermedius* isolates were obtained from dog patients with pyoderma or otitis externa, referred to our veterinary teaching hospital in Konkuk University from local animal clinics during the period of 2006–2008. Signalments of canine patients are summarized in Table 1. Unfortunately, details on medical history such as pretreatment of antibiotics were not available. However, six of them have not been exposed to fluoroquinolones. The other cases were referred from local animal hospitals and thus it is believed that they might be exposed to antibiotics.

Cotton swab specimens were collected from the canine skin or ear lesions and inoculated onto 5% (v/v) sheep blood agar plates. They were then incubated at 37°C for 24 to 48 h. Primary identification of staphylococci was made on the basis of colony morphology, Gram-staining, and conventional catalase test. The staphylococcal isolates were further tested for coagulase synthesis, lack of colony pigmentation, acetoin production, presence of β-galactosidase, and the PCR using the *S. intermedius*-specific primers as previously described [29]. Confirmative identification of *S. pseudintermedius* was done by the PCR–RFLP (restriction fragment length polymorphism) method recently developed by Bannoehr *et al*. [2].

Determination of Fluoroquinolone Resistance

All 74 *S. pseudintermedius* isolates were examined for their resistance to the five major fluoroquinolones as listed below, using a standard disc diffusion method, which followed the Clinical and Laboratory Standards Institute (CLSI) guidelines [18]. The fluoroquinolones and their disc contents were as follows: ciprofloxacin (5 μg; Becton, Dickinson and Company, U.S.A.), ofloxacin (5 μg; Becton, Dickinson and Company, U.S.A.), enrofloxacin (5 μg; Bayer HealthCare AG, Germany), levofloxacin (5 μg; Becton, Dickinson and Company, U.S.A.), and moxifloxacin (5 μg; Becton, Dickinson and Company, U.S.A.). Enrofloxacin is one of the widely used quinolones that were licensed for dogs in Korea as well as worldwide. The other 4 fluoroquinolones were selected among 2nd-, 3rd-, 4th-generation quinolones that have been generally used for human diseases.

Table 1. Signalments of canine patients in this study.

Skin disease	Number (N=56)	Percentage (%)
Atopic dermatitis	31	55.4
Superficial pyoderma	16	28.6
Food allergy	2	3.6
Hypothyroidism	1	1.8
Pododermatitis	1	1.8
Alopecia X	1	1.8
Bacterial folliculitis	1	1.8
Contact dermatitis	1	1.8
Eosinophilic frunculosis	1	1.8
[a]NA	1	1.8
Ear disease	**Number (N=18)**	**Percentage (%)**
Primary otitis externa	13	72.2
Atopic dermatitis	4	22.2
Ear polyp	1	5.6

[a]NA: Not available.

Briefly, *S. pseudintermedius* strains were cultured in Mueller–Hinton (MH) broth for 6–8 h. Bacterial cultures were adjusted to turbidity of 0.5 McFarland standard and inoculated on the MH agar plates using a cotton swab. The plates were then incubated for 24 h at 37°C. *S. aureus* ATCC 25923 and *E. coli* ATCC 25922 strains were used as a quality control for disk diffusion assay. According to the interpretive standards of Clinical Laboratory Standards Institute (CLSI) [18, 19], bacterial resistance was categorized into "Susceptible," "Intermediate resistant," and "Resistant." The percentage of the resistant populations against individual fluoroquinolones was calculated and compared with each other. In this study, multiple resistance was defined as bacterial resistance to three or more antimicrobial agents belonging to different subclasses.

Detection of the *mecA* Gene by PCR

The presence or absence of the *mecA* gene among the *S. pseudintermedius* isolates was determined by the PCR using the *mecA*-specific primers as previously described by Zubeir *et al*. [29].

Results

The results demonstrated that among the 74 *S. pseudintermedius* isolates, bacterial resistance was observed in 20, 19, 18,

Table 2. Fluoroquinolone resistance in the 74 *S. pseudintermedius* isolates from canine pyoderma and otitis externa in Korea.

Pattern of resistance [a]	Number of *S. pseudintermedius* isolates (%) resistant to [b]				
	CIP	OFX	ENR	LVX	MXF
Susceptible	49 (66.2)	51 (68.9)	31 (41.9)	55 (74.3)	50 (67.6)
Intermediate	6 (8.1)	5 (6.8)	23 (31.1)	4 (5.4)	10 (13.5)
Resistant	19 (25.7)	18 (24.3)	20 (27.0)	15 (20.3)	14 (18.9)

[a]See Materials and Methods.
[b]Abbreviations: CIP, ciprofloxacin; OFX, ofloxacin; ENR, enrofloxacin; LVX, levofloxacin; MXF, moxifloxacin.

Table 3. Fluoroquinolone resistance in the *mecA*-positive or -negative *S. pseudintermedius* isolates.

Pattern of fluoroquinolone resistance [a]	Number of *S. pseudintermedius* isolates (%)		
	mecA PCR-negative (N=49)	*mecA* PCR-positive (N=25)	
		OXA-R[b]	OXA-Susc[b]
NR	42 (85.7)	8 (32.0)	4 (16.0)
ENR	0 (0.0)	1 (4.0)	0 (0.0)
CIP+ENR	0 (0.0)	0 (0.0)	1 (4.0)
CIP+OFX+ENR	1 (2.0)	1 (4.0)	1 (4.0)
CIP+OFX+ENR+LVX	0 (0.0)	0 (0.0)	1 (4.0)
CIP+OFX+ENR+LVX+MFX	6 (12.2)	3 (12.0)	5 (20.0)

[a]Abbreviations: NR, no fluoroquinolone resistance, which represents both "susceptible" and "intermediate resistant" populations; ENR, enrofloxacin; CIP, ciprofloxacin; OFX, ofloxacin; LVX, levofloxacin; MFX, moxifloxacin. [b]OXA-R, resistant to oxacillin by disc diffusion assay; OXA-Susc, susceptible or intermediate resistance to oxacillin by disc diffusion assay.

15, and 14 isolates against enrofloxacin (27.0% resistance), ciprofloxacin (25.7% resistance), ofloxacin (24.3% resistance), levofloxacin (20.3% resistance), and moxifloxacin (18.9% resistance), respectively (Table 2). In addition, fluoroquinolones belonging to third- and fourth-generation drugs such as levofloxacin and moxifloxacin exhibited relatively less resistance than the other three belonging to second-generation drugs (Table 2). Notably, 19 (25.7%) isolates possessed resistances to two or more fluoroquinolones, including 14 isolates (18.9%) resistant to all the five fluoroquinolones tested (Table 3).

To investigate methicillin resistance among the 74 *S. pseudintermedius* isolates, a genetic marker for methicillin resistance, *mecA*, among those isolates was detected by the PCR using the *mecA*-specific primers as previously described by Zubeir *et al*. [29]. The PCR analysis showed that 25 out of 74 (33.8%) isolates carried the *mecA* gene, indicating a potential methicillin-resistant *S. pseudintermedius* population (Table 3). Those *mecA*-positive isolates appeared to be more resistant to fluoroquinolones than the *mecA*-negative isolates (Table 3). Indeed, 13 out of 25 (52.0%) *mecA*-positive isolates were resistant to at least one or more fluoroquinones, including 8 isolates carrying multiple resistance to all the five fluoroquinolones (Table 3). In contrast, only 7 out of 49 (14.3%) *mecA*-negative isolates were resistant to the fluoroquinolones evaluated in this study (Table 3).

DISCUSSION

One of the most surprising observations in this study was the high prevalence (13/25 isolates; 52.0%) of fluoroquinolone resistance among the *S. pseudintermedius* isolates carrying the *mecA* gene that were collected from canine pyoderma or otitis externa in our veterinary teaching hospital, Korea. In particular, 19 out of 20 fluoroquinolone-resistant isolates showed resistance to two or more fluoroquinolones licensed for both veterinary (enrofloxacin, ciprofloxacin, and ofloxacin) and human use (ciprofloxacin, ofloxacin, levofloxacin, and moxifloxacin), including 14 isolates resistant to all the five fluoroquinolones. To our knowledge, this is the first report on the prevalence of fluoroquinolone resistance as well as the presence of the *mecA* gene among *S. pseudintermedius* isolates from canine pyoderma and otitis externa.

In this study, fluoroquinolone resistance among the *S. pseudintermedius* isolates from canine pyoderma or otitis externa was greatly higher (18.9–27.0%) than those previously reported in other countries (less than 10%) such as Canada (6–8%) [8], France (2%) [6], the United Kingdom (0.7–1.2%) [15], Australia (0%) [7], Italy (1.5%) [10], Czech (0%) [17], Denmark (1.2%) [20], and Japan (0%) [24]. The observed high prevalence of fluoroquinolone resistance could be explained by the lack of strict regulation over fluoroquinolones in veterinary use and/or self-medication of fluoroquinolones by some dog breeders and pet owners in Korea. Supporting this notion, it has been recently reported that fluoroquinolone resistance is increased owing to antibiotics abuse in the farm animal industry [14] as well as in human medicine [13] in Korea.

On the basis of their antimicrobial activities and chemical structures, fluoroquinolones can be categorized into the second, third, and fourth generations. Certain mutations in their target proteins such as DNA gyrase or reduced uptake of those antibiotics are known to contribute to the development of bacterial resistance [22]. However, some fluoroquinolones such as moxifloxacin and gatifloxacin appear to slow the development of bacterial resistance, especially in Gram-positive bacteria species, because the two mutations are generally required for developing bacterial resistance [1, 22]. In this study, it was found that the highest resistance was observed with the veterinary-licensed enrofloxacin (27.0%), whereas the lowest was the human-licensed moxifloxacin (18.9%). Although several veterinary-licensed fluoroquinolones were introduced and recommended to use only in animals, their similarity in the chemical structures to human-licensed fluoroquinolones might induce cross-resistance against both veterinary- and human-use fluoroquinolones. As expected, 19 out of 20 (95.0%) fluoroquinolone-resistant isolates possessed resistance to two or more fluoroquinolones for both veterinary and human uses. Most surprisingly, 14 (73.7%) out of those 19 multi resistant *S. pseudintermedius* isolates were resistant to all the five fluoroquinolones tested, despite rare use of third or fourth generation fluoroquinolones such as moxifloxacin. These results imply that cross-resistances not only between veterinary- and human-use fluoroquinolones but also between rarely used third or fourth-generation

fluoroquinones are common among *S. pseudintermedius* isolates. Therefore, more specific care should be taken, and the antibiotic susceptibility test should be preceded before the prescription of fluoroquinolones.

Recently, a public health concern for multiple resistant *Staphylococcus* spp. against both methicillin and fluoroquinolones has been raised because of the restriction of antibiotic choice for staphylococcal infection [28]. Close association of methicillin-resistant *S. pseudintermedius* with high-level fluoroquinolone resistance has been reported [16], which is comparable to our results. Although the mechanisms behind the emergence of both fluoroquinolone- and methicillin-resistant *Staphylococcus* spp. are not clear, it has been proposed that inappropriate use of fluoroquinolones may potentiate bacterial adhesion mediated by the fibronectin-binding protein, which subsequently facilitates colonization of methicillin-resistant *S. aureus* [3], or may select high-level methicillin-resistant subpopulations in heteroresistant *S. aureus* [27]. It is noteworthy that 6 out of the 25 *mecA*-positive fluoroquinolone-resistant isolates (24.0%) have not been previously exposed to any antibiotics within 6 weeks before the sampling from dermatologic lesions, although prior exposure to antibiotics could not be reported for all the canine patients, implying possible transmission of the fluoroquinolone- and methicillin-resistant *S. pseudintermedius* between pet dogs and/or humans; however, further studies are needed to determine the prevalence of the community- or hospital-acquired fluoroquinolone- and methicillin-resistant *S. pseudintermedius* isolates. To date, transmission of *S. pseudintermedius* from dog to human by bite or contact has been described [12, 25]. In addition, human infection by this microorganism possibly community-acquired [26] as well as the emergence and prevalence of methicillin-resistant populations [23] have been recently reported. Therefore, the potential risk by the fluoroquinone- and methicillin-resistant *S. pseudintermedius* infections should be noted.

In conclusion, our data suggest the high prevalence of *S. pseudintermedius* isolates in Korea, which are resistant to both veterinary- and human-licensed fluoroquinolones as well as methicillin. Further studies would be necessary to prevent and/or minimize the emergence and spread of those high-level resistant populations as well as to develop an effective therapeutic strategy.

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References

1. Balfour, J. A. and L. R. Wiseman. 1999. Moxifloxacin. *Drugs* **57:** 363–373.
2. Bannoehr, J., A. Franco, M. Iurescia, A. Battisti, and J. R. Fitzgerald. 2009. Molecular diagnostic identification of *Staphylococcus pseudintermedius*. *J. Clin. Microbiol.* **47:** 469–471.
3. Bisognano, C., P. Vaudaux, P. Rohner, D. P. Lew, and D. C. Hooper. 2000. Induction of fibronectin-binding proteins and increased adhesion of quinolone-resistant *Staphylococcus aureus* by subinhibitory levels of ciprofloxacin. *Antimicrob. Agents Chemother.* **44:** 1428–1437.
4. Cohn, L. A., A. T. Gary, W. H. Fales, and R. W. Madsen. 2003. Trends in fluoroquinolone resistance of bacteria isolated from canine urinary tracts. *J. Vet. Diagn. Invest.* **15:** 338–343.
5. Devriese, L. A., M. Vancanneyt, M. Baele, M. Vaneechoutte, E. De Graef, C. Snauwaert, *et al.* 2005. *Staphylococcus pseudintermedius* sp. nov., a coagulase-positive species from animals. *Int. J. Syst. Evol. Microbiol*. **55:** 1569–1573.
6. Ganiere, J. P., C. Medaille, and C. Mangion. 2005. Antimicrobial drug susceptibility of *Staphylococcus intermedius* Clinical isolates from canine pyoderma. *J. Vet. Med. B* **52:** 25–31.
7. Gottlieb, S., D. Wigney, P. Martin, J. Norris, R. Malik, and M. Govendir. 2008. Susceptibility of canine and feline *Escherichia coli* and canine *Staphylococcus intermedius* isolates to fluoroquinolones. *Aust. Vet. J.* **86:** 147–152.
8. Hoekstra, K. A. and R. J. Paulton. 1996. Antibiotic sensitivity of *Staphylococcus aureus* and *Staph. intermedius* of canine and feline origin. *Lett. Appl. Microbiol.* **22:** 192–194.
9. Ihrke, P., M. Papich, and T. Demanuelle. 1999. The use of fluoroquinolones in veterinary dermatology. *Vet. Dermatol.* **10:** 193–204.
10. Intorre, L., M. Vanni, D. Di Bello, C. Pretti, V. Meucci, R. Tognetti, G. Soldani, G. Cardini, and O. Jousson. 2007. Antimicrobial susceptibility and mechanism of resistance to fluoroquinolones in *Staphylococcus intermedius* and *Staphylococcus schleiferi*. *J. Vet. Pharmacol. Ther.* **30:** 464–469.
11. Jones, R. D., S. A. Kania, B. W. Rohrbach, L. A. Frank, and D. A. Bemis. 2007. Prevalence of oxacillin- and multidrug-resistant staphylococci in clinical samples from dogs: 1,772 samples (2001–2005). *J. Am. Vet. Med. Assoc.* **230:** 221–227.
12. Lee, J. 1994. *Staphylococcus intermedius* isolated from dog-bite wounds. *J. Infect.* **29:** 105.
13. Lee, K., K. H. Park, S. H. Jeong, H. S. Lim, J. H. Shin, D. Yong, G. Y. Ha, Y. Chong, and K. group. 2006. Further increase of vancomycin-resistant *Enterococcus faecium*, amikacin- and fluoroquinolone-resistant *Klebsiella pneumoniae*, and imipenem-resistant *Acinetobacter* spp. in Korea: 2003 KONSAR surveillance. *Yonsei Med. J.* **47:** 43–54.
14. Lee, Y. J., J. K. Cho, K. S. Kim, R. B. Tak, A. R. Kim, J. W. Kim, S. K. Im, and B. H. Kim. 2005. Fluoroquinolone resistance and *gyrA* and *parC* mutations of *Escherichia coli* isolated from chicken. *J. Microbiol.* **43:** 391–397.
15. Lloyd, D., A. Lamport, W. Noble, and S. Howell. 1999. Fluoroquinolone resistance in *Staphylococcus intermedius*. *Vet. Dermatol.* **10:** 249–251.
16. Loeffler, A., M. Linek, A. Moodley, L. Guardabassi, J. Sung, M. Winkler, R. Weiss, and D. Lloyd. 2007. First report of multiresistant, *mecA*-positive *Staphylococcus intermedius* in

Europe: 12 cases from a veterinary dermatology referral clinic in Germany. *Vet. Dermatol.* **18:** 412–421.
17. Lyskova, P., M. Vydrzalova, and J. Mazurova. 2007. Identification and antimicrobial susceptibility of bacteria and yeasts isolated from healthy dogs and dogs with otitis externa. *J. Vet. Med. A Physiol. Pathol. Clin. Med*. **54:** 559–563.
18. NCCLS. 2008. *Performance Standards for Antimicrobial Disk and Dilution Susceptibility Tests for Bacteria Isolated from Animals*; Approved standard. CLSI document M31-A3. NCCLS, Wayne, PA.
19. NCCLS. 2009. *Performance Standards for Antimicrobial Susceptibility Testing*, Nineteenth Informational Supplement. CLSI document M100-S19 NCCLS, Wayne, PA.
20. Pedersen, K., H. Jensen, K. Finster, V. F. Jensen, and O. E. Heuer. 2007. Occurrence of antimicrobial resistance in bacteria from diagnostic samples from dogs. *J. Antimicrob. Chemother.* **60:** 775–781.
21. Pellerin, J. L., P. Bourdeau, H. Sebbag, and J. M. Person. 1998. Epidemiosurveillance of antimicrobial compound resistance of *Staphylococcus intermedius* clinical isolates from canine pyodermas. *Comp. Immunol. Microbiol. Infect. Dis.* **21:** 115–133.
22. Ruiz, J. 2003. Mechanisms of resistance to quinolones: Target alterations, decreased accumulation and DNA gyrase protection. *J. Antimicrob. Chemother.* **51:** 1109–1117.
23. Ruscher, C., A. Lubke-Becker, C. G. Wleklinski, A. Soba, L. H. Wieler, and B. Walther. 2009. Prevalence of methicillin-resistant *Staphylococcus pseudintermedius* isolated from clinical samples of companion animals and equidaes. *Vet. Microbiol.* **136:** 197–201.
24. Shimizu, A., Y. Wakita, S. Nagase, M. Okabe, T. Koji, T. Hayashi, *et al.* 2001. Antimicrobial susceptibility of *Staphylococcus intermedius* isolated from healthy and diseased dogs. *J. Vet. Med. Sci.* **63:** 357–360.
25. Tanner, M. A., C. L. Everett, and D. C. Youvan. 2000. Molecular phylogenetic evidence for noninvasive zoonotic transmission of *Staphylococcus intermedius* from a canine pet to a human. *J. Clin. Microbiol.* **38:** 1628–1631.
26. Van Hoovels, L., A. Vankeerberghen, A. Boel, K. Van Vaerenbergh, and H. De Beenhouwer. 2006. First case of *Staphylococcus pseudintermedius* infection in a human. *J. Clin. Microbiol*. **44:** 4609–4612.
27. Venezia, R. A., B. E. Domaracki, A. M. Evans, K. E. Preston, and E. M. Graffunder. 2001. Selection of high-level oxacillin resistance in heteroresistant *Staphylococcus aureus* by fluoroquinolone exposure. *J. Antimicrob. Chemother.* **48:** 375–381.
28. Weber, S. G., H. S. Gold, D. C. Hooper, A. W. Karchmer, and Y. Carmeli. 2003. Fluoroquinolones and the risk for methicillin-resistant *Staphylococcus aureus* in hospitalized patients. *Emerg. Infect. Dis.* **9:** 1415–1422.
29. Zubeir, I. E., T. Kanbar, J. Alber, C. Lammler, O. Akineden, R. Weiss, and M. Zschock. 2007. Phenotypic and genotypic characteristics of methicillin/oxacillin-resistant *Staphylococcus intermedius* isolated from clinical specimens during routine veterinary microbiological examinations. *Vet. Microbiol.* **121:** 170–176.