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# Bacterial Osteomyelitis Induced by *Morganella morganii* in a Bearded Dragon (*Pogona vitticeps*)

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**Abstract :** Bacterial osteomyelitis—or bacterial infection of the bone—is common in reptiles. Unfortunately, its treatment is challenging despite advances in diagnostic and medical technologies. Herein, we present the case of a sexually mature female bearded dragon (*Pogona vitticeps*) with left forelimb elbow joint stiffness. We diagnosed the reptile with a eft elbow joint traumatic structural abnormality based on gross examination and evaluation of radiographs. Treatment with clindamycin and cephalexin for bacterial infection failed and the reptile died. Necropsy revealed the causative bacteria as *Morganella morganii*. Treatment of osteomyelitis is typically focused against *Staphylococcus aureus* as it the most common cause of traumatic bone infection. However, *M. morganii*, the causative bacterium in this case, has a natural resistance to clindamycin and cephalexin. Recently, these bacteria have begun to appear in clinical reports, more commonly as the causative organisms of bone infections. *M. morganii* should be considered as a potential cause of infection. Furthermore, antibiotic treatment in such cases should be based on bacterial culture and susceptibility tests.

***Key words*** **:** antibiotics, bearded dragon, osteomyelitis, an opportunistic pathogen, *Morganella morganii*.

## Introduction

Bacterial osteomyelitis is a bacterial infection involving one or several portions of bone (8). General clinical signs and prognosis include bone destruction, stiffening of the joints, pathologic fracture, septicemia, and death. In reptiles, osteomyelitis is quite common (1) and is most often caused by wound contamination. Osteomyelitis usually involves the premaxilla, mandible, or tail (1). The most common causative organisms of osteomyelitis in reptiles are *Pseudomonas*, *Citrobacter*, *Escherichia coli*, *Salmonella*, *Proteus*, and *Staphylococcus* species (1). *Morganella morganii* (*M. morganii*) is a component of normal environmental flora and resides within the alimentary tracts of animals, including reptiles (9). In recent years, *M. morganii* has been found increasingly drug-resistant (12). Therefore, clinical treatment failures against *M. morganii* are emerging (9).

We describe the pathogenic origins of a osteomyelitis case in a bearded dragon. To the authors' best knowledge, this is the first description of bacterial osteomyelitis of a bearded dragon in Korea.

## Case Report

A female bearded dragon was presented for diagnosis and treatment of the elbow joint. The lizard was 2 years old and sexually mature. Further, it was 52 centimeters in snout-to-tail length and weighed 433 grams. The chief complaint was left elbow joint stiffness for 2 weeks. The joint was locked in a fixed position. On gross examination, the lizard's appetite was normal, and the body condition score was 3/5. The left elbow showed evidence of laceration recovery on the flexion side of the elbow joint. Moreover, the skin of the flexion part of the defected elbow joint was hardened. The distal part and phalanges showed pain reception and were responsive to stimuli. The other joints, such as the phalangeal joint and shoulder, had no remarkable issues.

A radiograph of the elbow joint revealed an abnormality in the elbow joint connection. A distal epiphysis lytic lesion was observed in the left humerus (Fig 1A). We suspected that the recovered laceration or trauma observed in the elbow joint was responsible for the elbow joint's discontinuity. Therefore, traumatic microorganism infection was also suspected. The antibiotics clindamycin (5 mg/kg, BID, PO, Full-

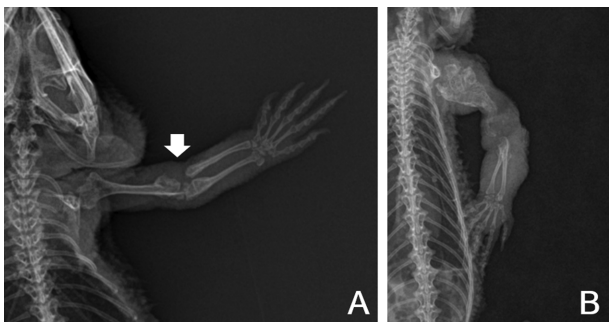


**Fig 1.** Radiographs. (A) Before humeral lysis, the first radiograph shows a distal epiphysis lytic lesion (white arrow) in the left humerus. (B) After humeral lysis. Expansile signs and multifocal destruction are observed.

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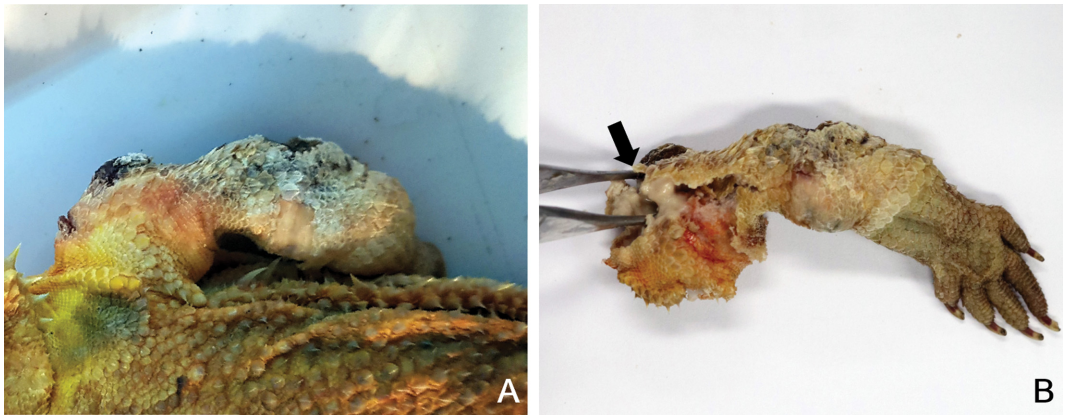


**Fig 2.** Necropsy. (A) Hyperkeratosis in the left forelimb. (B) Light-yellow pus in the bone space (black arrow).

gram cap.) and cephalexin (30 mg/kg, BID, PO, Falexin®) were administered to treat the condition.

After 1 month, the reptile was brought in again for examination. This time, the defects were not limited to the elbow joint but included the entire left forelimb. Hyperkeratosis was observed on the skin of the entire left forelimb (Fig 2). The body was in a severe under-conditioning state, and a loss of appetite and depression were observed. A hemogram revealed a high white blood cell count. Based on these clinical symptoms, the condition was considered an advanced stage of infection. Another radiograph was obtained that demonstrated expansile signs with cortical bone thinning and multifocal destruction with soft tissue swelling in the left arm (Fig 1B). To test antibiotic susceptibility, a biopsy and bacterial isolation were performed. Before identifying the responsible microbes, enrofloxacin (10 mg/kg, SID, IM, Baytril®) and meloxicam (0.3 mg/kg, SID, IM, Metacam®) were administered. After 2 days, the reptile died, and a post-mortem examination was performed.

Necropsy was performed as per the standard protocol. No remarkable findings were noted except for hyperkeratosis on the left forelimb (Fig 2A). Necropsy revealed light-yellow pus in the left humerus (Fig 2B). Bacteria were isolated from the organs and the pus. The organs were sectioned and imprinted on tryptic soy agar (TSA, Difco, New Jersey, USA) and incubated for 24 hours at 27°C. Isolates were identified by 16s rRNA gene sequencing and the sequence data was deposited in the NCBI Genbank (accession number; MW341450). The causative bacteria were identified as *M. morganii*; the same result was obtained from biopsy samples.

The antimicrobial susceptibility test was performed by disk diffusion to determine the minimal inhibitory concentration (MIC) value (Table 1). The bacterial strain was cultured on Mueller-Hinton agar (BD Difco, New Jersey, USA) for 18 hours at 35°C. The Vitek2 compact (bioMérieux, Marcy-l'Etoile, France) and AST-N224 cards were used to determine the MIC value. MIC of several antibiotics (e.g., amoxicillin/clavulanic acid, ampicillin, ciprofloxacin, imipenem, and trimethoprim/sulfamethoxazole, tend to be higher than that of the other antibiotics (5). Therefore, imipenem resistance was re-checked using the disk diffusion method. Disk diffusion and analysis were performed according to the M100S performance standard protocol for antimicrobial susceptibility testing 3rd Edition (Clinical Laboratory Standard Institute™, USA). The disk diffusion results showed that the bacteria were resistant to amoxicillin/clavulanic acid, ampicillin, ciprofloxacin, tetracycline, tigecycline, and trimethoprim/sulfamethoxazole, but did not produce extended-spectrum beta-lactamase (Table 1).

**Table 1.** Antimicrobial susceptibility test results

| Antibiotics | MIC | Disk diffusion |
|---|---|---|
| Amikacin | S | S |
| Ampicillin | R | R |
| Amoxicillin-clavulanic acid | R | - |
| Cefazolin | R | R |
| Ceftazidime | S | S |
| Cefotaxime | S | S |
| Cefepime | S | - |
| Cefoxitin | I | - |
| Ceftriaxone | - | S |
| Gentamicin | S | - |
| Ciprofloxacin | I | S |
| Imipenem | (R)* | I |
| Ertapenem | S | - |
| Meropenem | - | S |
| Aztreonam | S | S |
| Tigecycline | R | - |
| Tetracycline | - | R |
| Trimethoprim-sulfamethoxazole | R | - |
| Piperacillin-tazobactam | S | - |
| Extended spectrum beta lactamase | Negative | - |

I; intermediate, S; susceptible, R; resistant.
*Imipenem MIC tends to be higher (MIC in the intermediate and resistant range).

## Discussion

Osteomyelitis treatments are challenging despite advances in medical techniques and the discovery of novel antibiotics (8). In many cases, surgery and long-term antibiotic administration are necessary (1,2,8,13). Most microbes that cause osteomyelitis are opportunistic pathogens. Particularly, *Staphylococcus* infection has been reported most often (2,13). In our

case, we suspected osteomyelitis in its early stages based on radiography and medical history. Clindamycin and cephalexin were administrated to eliminate the causative microbes. Cephalexin—a first-generation cephalosporin—and clindamycin are commonly used to treat bone and joint infections (2,3,14). Both antibiotics have excellent bone penetration and can be administrated orally (3,14). Furthermore, cephalexin is a broad-spectrum antibiotic, and clindamycin is recommended for the treatment of *Staphylococcus* infections (14). However, in this case, the causative microbe was *M. morganii*. These bacteria are naturally resistant to clindamycin and first-generation cephalosporins (12). Furthermore, antimicrobial susceptibility tests showed that the isolated bacteria were also resistant to several other antibiotics used frequently in veterinary medicine, including amoxicillin/clavulanic acid, ampicillin, ciprofloxacin, tetracycline, tigecycline, and trimethoprim/sulfamethoxazole. For the treatment of osteomyelitis, proper antibiotic administration is important. Specifically, treatment should be based on bacterial culture and susceptibility tests.

Enrofloxacin is associated with well-known side effects in reptiles, including irritation or necrotization of the skin and muscles (6). In this case, enrofloxacin was administrated to the patient by intra-muscular injection. To avoid the side effect, we changed injection sites day-by-day. Some previous studies suggest oral administration of enrofloxacin in reptiles when repetitive or large volume injections are inevitable (6,7).

*M. morganii* is a facultative anaerobic Gram-negative rod-type bacterium belonging to the tribe *Proteeae*. Although unusual, is considered an opportunistic pathogen (10). Recently, several cases where *M. morganii* infection caused osteomyelitis and meningitis were reported (9-11,16)—including pneumonia, peritonitis, empyema, meningitis, and wound infections (10,15,16). This species is normally found in the oral cavity and intestinal tract (4,11). Although our case's infection was caused by a wound, it progressed to osteomyelitis. The osteoarticular pathologies caused by *M. morganii* rarely occur. Further, in cases with bony infections, local events *and* immunosuppression play important roles (9). Therefore, immunesuppressive factors should be considered in cases with bone infections occurred by *M. morganii*.

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## Authorship

Conceptualization, Jun Kwon and Se Chang Park; methodology, Sang Wha Kim; formal analysis, Sang Guen Kim; investigation, Jun Kwon; resources, Jun Kwon; writing—original draft preparation, Jun Kwon; writing—review and editing, Sib Sankar Giri and Hyoun Joong Kim; project administration, Se Chang Park.

## Conflicts of Interest

The authors declare no conflict of interest.

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