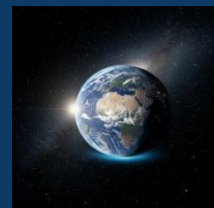




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Companion animal-associated bacterial pathogens and surgical site infections following orthopaedic procedures: implications for rehabilitation and return to physical activity – a narrative review

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Abstract

Background. Surgical site infections (SSIs) remain among the most serious complications of orthopaedic procedures, resulting in prolonged treatment, impaired functional recovery, delayed rehabilitation, and increased healthcare costs. Although most orthopaedic SSIs are caused by endogenous microorganisms, increasing evidence indicates that companion animal-

associated bacterial pathogens, including *Pasteurella multocida*, *Capnocytophaga canimorsus*, and *Staphylococcus pseudintermedius*, may occasionally cause postoperative and implant-associated infections following close contact with dogs and cats.

Aim. To summarize current evidence regarding companion animal-associated bacterial pathogens implicated in orthopaedic surgical site infections, discuss their routes of transmission and clinical significance, and evaluate their implications for postoperative rehabilitation and return to physical activity.

Material and methods. A narrative review of the contemporary literature was conducted. Publications addressing orthopaedic surgical site infections, zoonotic bacterial pathogens associated with companion animals, prosthetic joint infections, postoperative rehabilitation, and return to physical activity were critically reviewed and synthesized to provide an integrated overview of current knowledge.

Results. The available evidence indicates that companion animal-associated orthopaedic infections are rare and is based predominantly on case reports, case series, and a limited number of review articles. *Pasteurella multocida* represents the most frequently reported zoonotic pathogen, followed by *Capnocytophaga canimorsus* and *Staphylococcus pseudintermedius*. Transmission may occur through animal bites, scratches, licking of healing wounds, or close household contact. Surgical site infections substantially delay rehabilitation by prolonging wound healing, necessitating additional surgical procedures and antimicrobial therapy, and postponing return to physical activity. Current evidence supports patient education and simple hygiene measures rather than restricting contact with companion animals during postoperative recovery.

Conclusions. Companion animal-associated bacterial pathogens should be considered in selected cases of postoperative and implant-associated orthopaedic infections, particularly in patients with a history of close contact with dogs or cats. Awareness of zoonotic transmission pathways, careful exposure history taking, and appropriate patient education may reduce preventable infections while preserving the psychological and social benefits of companion animal ownership. Further prospective studies are required to establish the true incidence of these infections and to develop evidence-based recommendations for postoperative care.

Key words: surgical site infection; orthopaedic surgery; companion animals; zoonosis; rehabilitation; prosthetic joint infection; return to physical activity.

1. Introduction

Orthopaedic procedures, such as fracture fixation, joint arthroplasty and spinal surgery, are performed in increasing numbers worldwide and are highly effective in restoring mobility, relieving pain and improving quality of life. Successful outcomes, however, depend not only on the technical success of surgery but also on uncomplicated wound healing, effective rehabilitation and timely return to physical activity. Among postoperative complications, surgical site infections (SSIs) remain one of the most important because they are associated with prolonged hospitalization, repeated surgical interventions, increased healthcare costs and impaired functional recovery [4, 23, 33].

The microbiology of orthopaedic SSIs is dominated by endogenous pathogens, particularly *Staphylococcus aureus* and coagulase-negative staphylococci. Nevertheless, increasing attention has been directed towards less common zoonotic microorganisms associated with companion animals. Dogs and cats harbour diverse bacterial communities within the oral cavity, skin and hair coat, and close human–animal interaction creates opportunities for bacterial transmission through bites, scratches, saliva or routine household contact [40, 15]. Case reports and systematic reviews have repeatedly identified *Pasteurella multocida*, *Capnocytophaga canimorsus* and *Staphylococcus pseudintermedius* as causes of postoperative and implant-associated infection — a body of evidence that continues to grow despite the overall rarity of these events. [6, 3, 34]. As pet ownership continues to increase worldwide, awareness of these uncommon but clinically relevant pathogens has become increasingly important for orthopaedic surgeons, infectious disease specialists and rehabilitation professionals.

Beyond infection control, orthopaedic SSI has important implications for postoperative rehabilitation. Deep infections frequently necessitate prolonged antimicrobial therapy, additional surgical procedures and temporary restrictions in weight-bearing or joint mobilisation, thereby delaying functional recovery and return to physical activity [25, 13, 7]. Although companion animal-associated musculoskeletal infections have been described in numerous case reports, case series and recent reviews, their implications for postoperative rehabilitation and return to physical activity have received comparatively little attention in the literature [6, 3, 34].

This narrative review therefore aims to summarize current evidence regarding companion animal-associated bacterial pathogens implicated in orthopaedic surgical site infections, discuss their routes of transmission and clinical significance, and examine their implications for postoperative rehabilitation and return to physical activity. In addition, the review highlights

current evidence supporting patient education and simple preventive measures that may reduce the risk of zoonotic postoperative infection while allowing patients to maintain the psychological and social benefits associated with companion animal ownership.

To our knowledge, few reviews have integrated evidence on companion animal-associated bacterial pathogens, orthopaedic surgical site infections, postoperative rehabilitation and return to physical activity.

2. Surgical site infections after orthopaedic procedures

2.1. Definition and classification of surgical site infections

Surgical site infections (SSIs) are among the most serious complications following orthopaedic procedures, contributing to increased morbidity, repeated surgical interventions, prolonged hospitalization and substantial healthcare costs. Their impact is particularly pronounced in orthopaedic surgery, where successful treatment depends not only on infection control but also on the preservation of function and timely rehabilitation [4, 23, 44]

Standardized SSI classification is fundamental for clinical management, surveillance and comparison of outcomes across studies. The Centers for Disease Control and Prevention (CDC) categorizes SSIs as superficial incisional, deep incisional and organ/space infections according to the anatomical structures involved. In orthopaedic surgery, infections affecting bones, joints and implanted prosthetic materials are classified as organ/space infections and are associated with substantially greater therapeutic complexity than superficial wound infections [4, 17].

Among organ/space infections, periprosthetic joint infection (PJI) represents one of the most challenging complications of orthopaedic surgery because its management frequently requires a combination of surgical intervention and antimicrobial therapy. Distinguishing superficial wound infections from deep implant-associated infections is therefore crucial, as prognosis and treatment strategies differ considerably between these conditions [43, 22, 4].

2.2. Epidemiology and burden of surgical site infections

Although the incidence of surgical site infections (SSIs) following primary orthopaedic procedures is generally low, these infections remain among the most important healthcare-associated complications because of the increasing number of joint arthroplasties and other reconstructive procedures performed worldwide. Infection rates vary according to procedure type, patient characteristics and surveillance methods; however, even a low incidence translates into a considerable clinical and economic burden [4, 10, 33].

The risk of SSI is substantially higher following revision arthroplasty, trauma surgery and procedures involving prolonged operative time or extensive soft tissue injury. Such infections frequently require additional surgery, prolonged antimicrobial therapy and extended follow-up, making them one of the most challenging complications of orthopaedic surgery [10, 23, 22].

Accurate estimates of SSI incidence depend on effective postoperative surveillance. As hospital stays become shorter, a substantial proportion of infections become clinically apparent only after discharge. Approximately half of orthopaedic SSIs are identified during post-discharge follow-up, emphasizing the importance of surveillance programmes extending beyond hospitalization [41].

2.3. Risk factors and microbiological characteristics of orthopaedic surgical site infections

SSI develops through a multifactorial interaction of patient-, procedure- and microbiology-related factors, rather than any single determinant [10, 4, 23]. Patient-related risk factors — advanced age, obesity, diabetes mellitus, smoking, malnutrition, immunosuppression and a history of previous SSI — impair host defence and wound healing, with cumulative comorbidity burden mattering more than any individual factor [10, 23, 4].

Procedure-related risk increases with revision surgery, prolonged operative time, extensive soft tissue dissection, greater blood loss, and the use of orthopaedic implants, which provide a surface for bacterial adhesion and subsequent biofilm formation [10, 41, 23, 43]. Once established, biofilms shield microorganisms from host immunity and substantially reduce antimicrobial susceptibility, making implant-associated infections difficult to eradicate without combined surgical and antimicrobial treatment [43, 22].

Gram-positive organisms originating from the patient's own skin and nasal flora dominate the microbiology of orthopaedic SSI. *Staphylococcus aureus*, particularly via nasal carriage, remains the leading cause and a well-established predictor of postoperative infection, supporting preoperative screening and decolonisation in selected patients [18]. Coagulase-negative staphylococci are also important owing to their strong biofilm-forming capacity, while Gram-negative organisms and polymicrobial infections — including *Escherichia coli*, *Klebsiella pneumoniae* and *Pseudomonas aeruginosa* — are increasingly recognised in revision procedures and complex, multimorbid patients, complicating antimicrobial management [18, 43, 22, 41].

Accurate microbiological diagnosis underpins targeted therapy: beyond conventional culture, implant sonication, PCR and next-generation sequencing improve pathogen detection, particularly in culture-negative periprosthetic joint infection [43, 22, 4].

2.4. Prevention, surveillance and clinical consequences

Prevention of orthopaedic SSI relies on a multimodal approach — patient optimisation, appropriate antimicrobial prophylaxis, meticulous surgical technique and effective postoperative surveillance — since no single measure eliminates risk arising from multiple interacting factors [4, 10]. Optimising modifiable factors such as glycaemic control and smoking cessation, together with screening and targeted decolonisation of *S. aureus* carriers, has become a standard component of prevention before elective arthroplasty [4, 10, 18]. Surveillance must extend beyond discharge: approximately half of orthopaedic SSIs are identified only during post-discharge follow-up [4, 41].

When prevention fails, the clinical consequences are substantial. Patients typically require prolonged antimicrobial therapy, additional surgical interventions and extended follow-up, increasing costs and slowing recovery relative to uncomplicated courses [23, 22, 33]. Beyond the direct burden of treatment, SSI delays functional recovery by prolonging pain, limiting mobility and postponing rehabilitation, with implant-associated infections often requiring staged procedures that further extend recovery and impair patient-reported outcomes [33, 22, 23]. Taken together, these consequences show that managing orthopaedic SSI successfully requires not only infection eradication but also preservation of function through timely diagnosis and multidisciplinary postoperative care [4, 22, 43].

3. Companion animal-associated bacterial pathogens

3.1. Companion animals as reservoirs of bacterial pathogens

Companion animals harbour diverse microbial communities within the oral cavity, skin and hair coat, constituting important reservoirs of microorganisms with zoonotic potential. Bites and scratches are the classical route of pet-associated infection, but they are not the only one: routine interactions — petting, grooming, sharing living space — can transfer microorganisms just as effectively, without any recognisable trauma. Consequently, dogs and cats should be considered not only as sources of bite-related infections but also as potential reservoirs of pathogens relevant to postoperative wound contamination [40, 15].

The canine oral cavity contains a highly diverse microbiota comprising more than 350 bacterial taxa, including clinically important genera such as *Pasteurella*, *Capnocytophaga*, *Porphyromonas*, *Neisseria* and *Fusobacterium*, many of which have been implicated in zoonotic infections. Similarly, the feline oral microbiota is dominated by Gram-negative

bacteria, particularly *Pasteurella spp.*, followed by *Neisseria spp.* and *Staphylococcus spp.*, reflecting the organisms most frequently recovered from cat bite-associated infections [8, 5]. In addition to the oral cavity, both dogs and cats harbour complex and dynamic microbial communities on their skin and hair coat. Modern sequencing studies have demonstrated that these cutaneous microbiota are considerably more diverse than previously recognised and are influenced by anatomical location, host characteristics, environmental exposure and skin health. Importantly, dermatological disease may disrupt microbial homeostasis and promote colonisation by opportunistic bacteria, particularly *Staphylococcus spp.* [35, 28, 29]. The clinical relevance of these microbial reservoirs is supported by studies demonstrating bacterial exchange between companion animals and their owners. Individuals living with dogs share significantly more skin-associated microorganisms with their pets than with unrelated animals, indicating that close cohabitation facilitates microbial transfer. Moreover, routine behaviours such as petting, licking, sharing household environments and inadequate hand hygiene may provide opportunities for indirect transmission of bacteria without the need for traumatic exposure. Although the direct contribution of these interactions to surgical site infections remains poorly defined, they represent biologically plausible mechanisms of bacterial contamination during the vulnerable postoperative period following orthopaedic surgery [40, 15].

3.2. *Pasteurella multocida*

Pasteurella multocida is the most frequently reported zoonotic pathogen associated with orthopaedic postoperative infections following exposure to companion animals. *P. multocida* is responsible for more reported implant-associated infections than any other companion animal-derived bacterial species — this despite prosthetic joint infection itself remaining an uncommon complication overall. The growing number of published cases, including recent systematic reviews encompassing more than 50 prosthetic joint infections, highlights the clinical relevance of this organism for orthopaedic surgeons and infectious disease specialists [6, 45].

P. multocida is a Gram-negative coccobacillus that forms part of the normal oral and upper respiratory microbiota of many domestic animals. Colonisation rates reach approximately 70–90% in cats and 20–50% in dogs, making companion animals an important reservoir for human infection. Several reported cases involved no identifiable bite or scratch at all — the only exposure being saliva contact or wound licking, discovered retrospectively once *P. multocida* was already isolated. Several reports have demonstrated that no obvious animal-inflicted injury

can be identified, and in many patients a history of pet exposure was elicited only after microbiological identification of *P. multocida* [46, 32, 6].

The clinical manifestations of *P. multocida* infection range from skin and soft tissue infections to bacteraemia, respiratory tract infections, endocarditis, meningitis and septic arthritis. Nevertheless, its greatest relevance to orthopaedic practice lies in its ability to infect implanted biomaterials. Prosthetic joint infection represents the best recognised orthopaedic manifestation, with total knee arthroplasty accounting for the majority of reported cases, followed by hip and shoulder arthroplasties. Most patients are older adults with underlying comorbidities such as diabetes mellitus, rheumatoid arthritis or other forms of immunosuppression, although infection has also been reported in otherwise immunocompetent individuals [47, 45, 6].

Accumulating evidence suggests that postoperative infection may develop through several distinct mechanisms. Direct inoculation following animal bites or scratches remains well documented, but an increasing number of reports describe infections after dogs or cats licked postoperative wounds or intact skin adjacent to recent surgical incisions. Furthermore, haematogenous seeding following transient bacteraemia has been described after seemingly trivial animal exposure. A recurring observation across published cases is that patients rarely volunteer information regarding pet ownership unless specifically questioned, emphasising the importance of obtaining a detailed exposure history in patients presenting with unusual musculoskeletal infections [11, 19, 6].

Prosthetic joint infection is the predominant presentation, but *P. multocida* should also be recognised as a cause of other postoperative orthopaedic infections. Early surgical site infection following lumbar spinal arthrodesis has recently been reported in a patient whose only recognised exposure was close contact with a household cat. Despite repeated debridement procedures and prolonged targeted antimicrobial therapy, definitive infection control required replacement of the spinal instrumentation, illustrating the therapeutic challenges associated with implant-related *Pasteurella* infections [9]. Similar observations from prosthetic joint infections suggest that bacterial adherence to implanted biomaterials and biofilm formation may contribute to treatment failure, although direct evidence remains limited [45, 6].

Most *P. multocida* isolates remain susceptible to penicillin, aminopenicillins, β -lactam/ β -lactamase inhibitor combinations, third-generation cephalosporins and fluoroquinolones, whereas first-generation cephalosporins, oxacillin, clindamycin and dicloxacillin generally provide inadequate empirical coverage. Early diagnosis, appropriate surgical management and targeted antimicrobial therapy are associated with favourable outcomes in most reported cases.

Equally important is patient education regarding avoidance of animal bites, scratches and licking of postoperative wounds during the early healing period, a point clinicians should stress explicitly when the patient has recently received an implant, since the consequences of infection are disproportionately higher in this group. [46, 32, 6].

3.3. *Capnocytophaga canimorsus*

Capnocytophaga canimorsus is a fastidious, capnophilic Gram-negative bacillus that forms part of the normal oral microbiota of dogs and, less frequently, cats. Not every case fits the expected pattern. Scratches, licking and even contact without any visible injury have all been documented as sufficient for transmission, alongside the more typical route of dog bites. Although severe infections occur predominantly in individuals with recognised risk factors, including asplenia, chronic alcohol misuse, liver disease and immunosuppression, approximately 40% of reported infections occur in apparently immunocompetent hosts [48, 3]

Unlike *Pasteurella multocida*, orthopaedic infections caused by *C. canimorsus* are exceedingly rare. Published reports consist almost exclusively of isolated prosthetic joint infections involving hip and knee arthroplasties, with only a handful of cases described over the past two decades. Nevertheless, these reports consistently demonstrate the organism's ability to cause late haematogenous infection of orthopaedic implants following exposure to companion animals [48, 49, 50, 51, 3].

One of the most important clinical characteristics of *C. canimorsus* is the diagnostic challenge it presents. The organism grows slowly under capnophilic and anaerobic conditions, and routine cultures frequently remain negative despite prolonged incubation. Several published cases of prosthetic joint infection were ultimately diagnosed only by broad-range 16S rRNA polymerase chain reaction after repeated negative cultures, suggesting that *C. canimorsus* may represent an under-recognised cause of culture-negative implant-associated infection. Consequently, molecular diagnostic techniques should be considered when conventional microbiological investigations fail to identify a pathogen in patients with a compatible clinical presentation and a history of dog or cat exposure [50, 3].

Immunosuppression remains an important predisposing factor, yet a recognised bite or scratch appears not to be essential for transmission, according to recent reports. Burger et al. described bilateral prosthetic knee infections in a patient receiving chronic corticosteroid therapy who owned four dogs but reported no history of animal-inflicted injury, supporting the hypothesis of transient bacteraemia following close contact with companion animals. Similar observations

have been reported in earlier cases, highlighting the importance of obtaining a detailed history of pet ownership even when obvious animal-related trauma is absent [49, 50, 3].

Most reported patients required surgical intervention, most commonly two-stage revision arthroplasty combined with prolonged β -lactam-based antimicrobial therapy, with favourable outcomes following appropriate management. Successful treatment has been achieved using prolonged antimicrobial therapy in combination with staged revision procedures, although the optimal strategy remains uncertain because current evidence is limited to isolated case reports [51, 52, 3].

The evidence base is limited to case reports and small case series, but this should not discourage clinicians from considering *C. canimorsus* in the differential diagnosis of culture-negative prosthetic joint infection, particularly in patients with recent dog or cat exposure or underlying immunosuppression. Early use of molecular diagnostic techniques, including broad-range 16S rRNA gene PCR, may facilitate pathogen identification when routine cultures remain negative [48, 26, 3].

3.4. *Staphylococcus pseudintermedius*

Staphylococcus pseudintermedius is a coagulase-positive staphylococcus and the predominant commensal bacterium of dogs, colonising the skin and mucosal surfaces of up to 90% of healthy animals. Although it forms part of the normal canine microbiota, it is also the leading cause of pyoderma, otitis externa and postoperative wound infections in dogs. Cats may also be colonised, although less frequently. Owing to the close relationship between humans and companion animals, *S. pseudintermedius* has emerged as an important zoonotic pathogen within the One Health framework. Human acquisition is primarily associated with close contact with dogs, while molecular studies have demonstrated sharing of genetically related strains between pets and their owners, supporting interspecies transmission [34, 24].

The true incidence of human infection is likely underestimated. Until recently, *S. pseudintermedius* was frequently misidentified as *Staphylococcus aureus* or reported as a member of the *Staphylococcus intermedius* group because of the limitations of conventional biochemical identification methods. The introduction of matrix-assisted laser desorption/ionisation time-of-flight mass spectrometry (MALDI-TOF MS) and molecular techniques has substantially improved species-level identification and has led to increasing recognition of this organism in clinical practice [38, 39, 44, 34].

Most reported human infections involve skin and soft tissue, yet the clinical spectrum is considerably broader and includes bacteraemia, infective endocarditis, catheter-related

infections, sinusitis, surgical site infections and musculoskeletal infections [38, 34]. In the largest population-based series published to date, Somayaji et al. identified 24 patients with *S. pseudintermedius* infection, of whom 92% had documented contact with dogs. Skin and soft tissue infections accounted for 75% of cases, whereas invasive disease included a prosthetic joint infection and a bloodstream infection. Importantly, methicillin-resistant *S. pseudintermedius* (MRSP) was identified in 12.5% of patients, and all MRSP isolates exhibited multidrug resistance [38, 39].

Orthopaedic infections remain uncommon, but the available evidence is unambiguous: *S. pseudintermedius* should be recognised as a potential cause of implant-associated infection in patients with companion animal exposure. Wang et al. reported the first prosthetic joint infection caused by a member of the *Staphylococcus intermedius* group following revision elbow arthroplasty, highlighting the possibility of postoperative inoculation associated with close dog contact. More recently, Ota et al. described methicillin-resistant *S. pseudintermedius* mediastinitis after cardiac surgery and proposed preoperative skin colonisation rather than direct postoperative contamination by a pet as the most plausible mechanism of infection. Together, these observations support the concept that asymptomatic colonisation may precede postoperative infection following disruption of normal skin barriers and implantation of foreign material [44, 30].

The emergence of MRSP further increases the clinical importance of this organism. Similar to methicillin-resistant *S. aureus*, resistance is mediated by the *mecA* gene and is frequently accompanied by resistance to multiple antimicrobial classes, including fluoroquinolones, macrolides and tetracyclines. In addition, *S. pseudintermedius* possesses several virulence characteristics, including biofilm formation and adherence to host tissues, which may facilitate persistence on implanted biomaterials and complicate eradication of infection. Consequently, accurate microbiological identification and antimicrobial susceptibility testing are essential, particularly in patients presenting with unusual postoperative or prosthetic joint infections and a history of close contact with dogs [38, 39, 24, 34].

3.5. Other pathogens

Several additional zoonotic microorganisms have occasionally been implicated in musculoskeletal infections following companion animal contact, although the evidence is limited almost exclusively to isolated case reports. *Bordetella bronchiseptica*, a respiratory pathogen of dogs and cats, has caused sporadic orthopaedic infections mainly in immunocompromised individuals [14, 2, 16]. *Corynebacterium ulcerans* has been transmitted

from household pets with confirmed genetic relatedness between human and animal isolates, though orthopaedic involvement is exceptionally rare [37]. *Erysipelothrix rhusiopathiae* prosthetic joint infections have also been reported, but almost exclusively following occupational exposure to livestock rather than companion animals, and only nine cases have been described to date [1]. Collectively, these organisms remain negligible contributors to companion animal-associated orthopaedic infection compared with *P. multocida*, *C. canimorsus* and *S. pseudintermedius*.

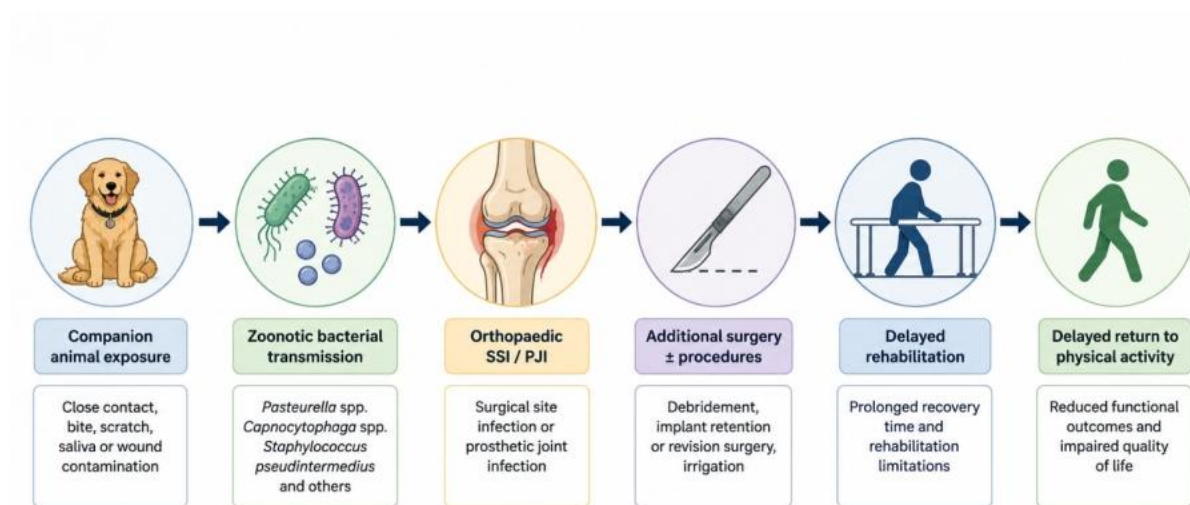
3.6. Routes of transmission

The companion animal-associated bacterial pathogens discussed in this review exhibit considerable diversity in their microbiological characteristics and pathogenic potential. Nevertheless, they share several common routes of transmission. Direct inoculation following animal bites and scratches remains the best-recognised mechanism; however, several documented cases show that companion animal-associated orthopaedic infections can also arise following contamination of surgical wounds with saliva, close household contact, or transient bacteraemia in the absence of recognised trauma. Consequently, the absence of a documented bite or scratch should not exclude the possibility of zoonotic infection, a caveat that matters most for patients carrying prosthetic material, where an unexplained infection is rarely 'just' a coincidence [6, 3, 34].

From a clinical perspective, careful assessment of companion animal exposure should form part of the routine evaluation of patients presenting with postoperative or prosthetic joint infection. A detailed history of pet ownership, recent bites or scratches, wound licking and other close animal contact may provide valuable diagnostic clues and facilitate appropriate microbiological investigation, including molecular techniques when conventional cultures remain negative [6, 3, 26]. Likewise, patients undergoing orthopaedic procedures should be advised to avoid animal contact with healing wounds and to seek prompt medical attention following bites or scratches during the postoperative period [46, 32, 6].

Companion animal-associated orthopaedic infections remain uncommon today, but increasing pet ownership and close human–animal interaction may raise the frequency with which orthopaedic surgeons encounter these pathogens. Greater awareness of zoonotic transmission pathways, careful exposure history taking and appropriate preventive measures may facilitate earlier diagnosis, targeted antimicrobial therapy and improved outcomes in this unique group of postoperative infections [3, 34, 6].

4. Implications for rehabilitation and return to physical activity



Source: Prepared by the authors based on the cited literature.

[Figure 1. Proposed pathway linking companion animal exposure with delayed postoperative rehabilitation](#)

4.1. Impact of surgical site infections on rehabilitation

Surgical site infections (SSIs) significantly alter the postoperative rehabilitation pathway following orthopaedic procedures. Compared with uncomplicated recovery, patients with SSI often require prolonged wound management, extended antibiotic therapy, and additional surgical procedures, resulting in delayed functional recovery [13, 30].

Delayed wound healing is one of the earliest consequences of SSI. Persistent inflammation, wound drainage, and soft tissue damage frequently postpone rehabilitation milestones, including progression of range-of-motion exercises and strengthening programmes [13].

Deep infections may also require temporary restriction of weight-bearing or modification of rehabilitation protocols, particularly after debridement or revision surgery. These limitations contribute to muscle weakness, joint stiffness, reduced mobility, and prolonged recovery time [25].

Management of SSI commonly involves additional surgical procedures, including irrigation and debridement, implant retention, or revision surgery. Each subsequent intervention interrupts rehabilitation and may prolong hospitalization, delaying the patient's return to independent function [25, 13].

The negative impact of SSI on rehabilitation is reflected in functional outcome studies. In a multicentre cohort of more than 2,100 patients with high-risk fractures, Gitajn et al.

demonstrated that deep SSI was independently associated with significantly worse physical function six months after surgery, as measured by the Veterans RAND-12 Physical Component Score [13].

Similarly, Naumann et al. reported that patients who developed deep SSI after operative fixation of closed ankle fractures had significantly poorer long-term functional outcomes than patients without infection, including lower Olerud-Molander Ankle Scores and Lower Extremity Functional Scale scores at a median follow-up of more than four years [27].

Overall, current evidence indicates that SSI affects rehabilitation far beyond infection control alone. Delayed healing, restricted weight-bearing, and repeated surgical procedures contribute to slower recovery and poorer long-term physical function, emphasizing the importance of preventing postoperative infections to optimize rehabilitation [13, 27].

4.2. Return to physical activity

The primary goal of rehabilitation following orthopaedic surgery is to enable patients to safely return to their previous level of physical activity. In uncomplicated cases, return to activity depends on successful wound healing, restoration of joint function, adequate muscle strength, and completion of procedure-specific rehabilitation protocols [42].

The development of surgical site infection, particularly prosthetic joint infection (PJI), may substantially delay this process. Treatment often requires prolonged antimicrobial therapy together with debridement, implant retention procedures, or one- or two-stage revision surgery, resulting in extended recovery and delayed return to daily and recreational activities [25].

Even after successful eradication of infection, functional recovery may remain incomplete. Mur et al. demonstrated that patients treated successfully for PJI were significantly more likely to require walking aids than matched patients without infection, indicating persistent limitations in mobility despite microbiological cure [25].

Similarly, Cooper et al. reported that patients with PJI had substantially reduced physical quality-of-life scores at diagnosis, and although these improved during follow-up, only approximately 40% achieved a good functional outcome after 12 months. Successful treatment increased the likelihood of better physical recovery, yet many patients continued to experience functional impairment compared with the general population [7].

Long-term follow-up studies further indicate that patients treated for PJI remain at risk of late reinfection, including recurrence occurring more than five years after reimplantation. Consequently, long-term clinical surveillance and patient education remain important even after apparent treatment success [12].

4.3. Companion animals during rehabilitation

Companion animals may provide important psychological and physical benefits during postoperative rehabilitation by improving emotional well-being, reducing social isolation, and encouraging daily activity. However, the early postoperative period may also represent a time of increased susceptibility to wound contamination before complete healing has occurred.

Current evidence linking companion animals with surgical site or prosthetic joint infections remains limited and consists predominantly of case reports and small case series. Nevertheless, several zoonotic pathogens commonly associated with dogs and cats, including *Pasteurella multocida*, *Streptococcus canis*, *Staphylococcus pseudintermedius*, and *Capnocytophaga canimorsus*, have been implicated in postoperative and implant-associated infections in humans [31, 21, 24, 3].

Among these organisms, *Staphylococcus pseudintermedius* has attracted increasing attention as an emerging zoonotic pathogen because it colonizes the skin and mucous membranes of the majority of healthy dogs and has been shown to colonize humans with frequent canine contact. Although human infections remain uncommon, they have been reported primarily in dog owners and immunocompromised individuals, highlighting the importance of considering animal exposure during the diagnostic evaluation of unusual postoperative infections [24].

Pasteurella species represent the best documented example of companion animal-associated prosthetic joint infection. A recent comprehensive review identified 57 published cases of *Pasteurella* prosthetic joint infections, with transmission occurring most commonly following animal bites, scratches, or direct licking of wounds by dogs and cats. Notably, the history of animal exposure often became apparent only after microbiological identification of the pathogen, suggesting that patients frequently underestimate the clinical significance of seemingly minor animal-related injuries. The interval between animal contact and onset of infection ranged from several days to five months, further complicating recognition of the zoonotic source.

Reported mechanisms of transmission extend beyond direct wound contamination. Case reports have described infections following licking of healing surgical wounds, contamination of postoperative drains, and hematogenous spread after apparently minor bites or scratches occurring at sites distant from the prosthetic joint [31, 36, 6].

Despite these reports, current evidence does not support considering pet ownership itself as a risk factor for surgical site or prosthetic joint infection, and routine separation of patients from companion animals is not recommended. Instead, available evidence consistently supports

patient education regarding simple preventive measures. Patients should be advised to avoid direct contact between pets and healing wounds or dressings, prevent animals from licking surgical incisions, protect postoperative drains and other medical devices from animal contact, perform appropriate hand hygiene after handling pets, and seek prompt medical assessment following animal bites or scratches, particularly in the presence of orthopaedic implants or immunocompromising conditions [31, 21, 6].

Taken together, the transmission routes described above indicate that companion animal-associated infection does not require an obvious bite or scratch — casual contact, saliva exposure and asymptomatic colonisation appear sufficient in several documented cases. This has direct diagnostic implications: exposure history should be sought routinely, not only when trauma is reported.

Patients recovering from orthopaedic surgery frequently ask practical questions regarding everyday interactions with companion animals. Although direct evidence is limited, several recommendations can be derived from published case reports, infection prevention principles and expert opinion. Frequently encountered clinical questions and evidence-informed counselling points are summarized in (Table 1).

Table 1. Frequently asked questions from patients with companion animals after orthopaedic surgery.

Clinical question	Current evidence	Practical advice
Can my pet lick my surgical wound?	Multiple case reports describe postoperative and prosthetic joint infections following wound licking.	No. Pets should not be allowed to lick healing wounds, dressings or surrounding skin.
Can I change my dressing while my pet is in the room?	No direct evidence available.	Dressing changes should be performed in a clean environment, ideally away from pets, to minimize accidental contamination.
Should I wash my hands after touching my pet before wound care?	Supported by general infection prevention principles.	Yes, hand hygiene should always precede wound care.

What if my pet Multiple reports describe Seek prompt medical evaluation, bites or scratches implant infections after bites particularly if orthopaedic implants are me after surgery? or scratches. present.

Should I get rid of No. Routine separation from companion my pet after No evidence supports this. animals is not recommended; simple surgery? hygiene precautions are sufficient.

Bed sharing itself has not been shown to Can my pet sleep in No studies have specifically increase SSI risk; however, direct contact my bed after evaluated bed sharing and between pets and healing wounds or surgery? SSI risk. dressings should be avoided until complete wound healing.

Source: Authors' own compilation based on the cited literature.

5. Clinical implications and future directions

Surgical site infections remain one of the most important complications of orthopaedic procedures because they prolong treatment, delay rehabilitation, and negatively affect long-term functional outcomes and quality of life. Therefore, prevention should remain a priority throughout the perioperative period, including patient education during postoperative rehabilitation.

In practice, this translates into a short set of actionable measures — summarised in Table 1 — that can be delivered during routine postoperative counselling without requiring specialist referral or restricting pet ownership. Their uptake, however, has not been formally studied, and adherence data are currently unavailable.

Despite increasing recognition of zoonotic pathogens such as *Pasteurella multocida*, *Staphylococcus pseudintermedius*, *Streptococcus canis*, and *Capnocytophaga canimorsus*, important gaps remain in the literature. Most published evidence consists of individual case reports or small case series, while prospective cohort studies evaluating the incidence, risk factors, and clinical outcomes of companion animal-associated orthopaedic infections are lacking. Consequently, the true burden of these infections and the effectiveness of preventive measures remain uncertain.

Another important limitation is the absence of dedicated evidence-based recommendations addressing companion animal contact during postoperative recovery. Current infection

prevention guidelines focus primarily on surgical and patient-related risk factors and provide little specific guidance regarding pet ownership or zoonotic transmission in orthopaedic patients.

Future research should therefore focus on prospective multicentre studies with standardized reporting of animal exposure, microbiological findings, treatment strategies, and rehabilitation outcomes. In addition, molecular epidemiological techniques could help confirm transmission pathways between companion animals and humans. Such evidence would support the development of practical, evidence-based recommendations that reduce infection risk while preserving the psychological and social benefits of companion animal ownership.

6. Conclusions

Companion animal-associated orthopaedic infections are rare but clinically important, particularly in patients with prosthetic implants or a history of close contact with dogs or cats. Given the limited evidence base — largely case reports and small series — routine separation from pets is not warranted; targeted patient education and basic hygiene measures remain the more proportionate response. Prospective studies are needed to define true incidence and to support formal recommendations.

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