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A retrospective cohort study on SSI rate in patella luxation surgery without prophylactic application of antimicrobials in dogs

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1. Introduction

Surgical site infections (SSI) pose a significant risk following orthopedic procedures, and their management presents a critical challenge in veterinary medicine, especially concerning the welfare of canines. Patellar luxation, characterized as one of the most common orthopedic issues in dogs, necessitates surgical intervention for correction. While the application of prophylactic antimicrobials has historically been an integral aspect of postoperative care to prevent infection, the emerging concerns of antimicrobial resistance have prompted the reevaluation of their routine use.

Therefore, the aim of the study is to investigate the hypothesis that the administration of antimicrobial prophylaxis in canine patellar luxation surgery is not necessary to maintain the overall rate of SSI at a level comparable to published data for clean orthopedic surgery in dogs. This retrospective study regarding the patella luxation surgery over more than hundreds of dogs aims to provide insights into surgical outcomes, owner satisfaction and the impact of antibiotic use on infection rates. That in question is accomplished by investigating the incidence of SSI in dogs undergoing patellar luxation surgery without peri- or postoperative prophylactic antimicrobial administration. Through the evaluation of the association between antibiotic administration and SSI rates in patellar luxation surgery, this study intends to provide supplementary information regarding the need for antimicrobial prophylaxis in clean orthopedic surgery.

2. Literature review

2.1 Overview of patellar luxation and its diagnosis

Patella luxation is classified as one of the most common orthopedic problems in canines within veterinary practice.[1] It can be divided into several categories, including medial luxation in toy and miniature dogs, which is the most common. Although it can also occur in large dog breeds, medial patellar luxation is 12 times more common in small dog breeds than in larger ones. Another category is lateral patellar luxation, which is commonly seen in larger dogs, but sometimes also in toy and miniature dogs. In addition to these two categories, there are rare cases of medial luxation as a result of trauma.[2, 3] In the past, patellar luxation was generally diagnosed mainly in small dogs. In recent years, however, there has been a significant increase in the prevalence of this condition in larger dogs.[4]

Patellar luxation is a condition in which the kneecap dislocates or shifts from its usual position at the base of the femur. Due to this displacement, the kneecap can move irregularly in the knee joint, preventing the dog from being able to bend its knee. The abnormal movement causes substantial friction on the joint surfaces, which gradually leads to osteoarthritis. In certain cases, the patella may remain permanently displaced from its normal position, leading to persistent impairment and difficulties in walking.[5]

In addition, around 15% to 20% of middle-aged and older dogs suffering from chronic patellar luxation also develop a concurrent rupture of the cranial cruciate ligament. This occurs because the quadriceps mechanism can no longer effectively stabilize the joint, which leads to increased stress on the cruciate ligament. Besides, the leg is turned inwards, which further stretches the cruciate ligament in such a situation. [2, 6]

The quadriceps, the patellar tendon, the patella, the patellar ligament, and the tibial tuberosity form the extensor mechanism of the knee joint. Ideally, this mechanism should run in a straight line from the proximal femur to the center of the hock. In animals with patellar luxation, misalignment of the extensor mechanism is common, even when attempts are made to reduce the patella. This misalignment contributes to the occurrence of the luxation.[2] Despite thorough research, the exact cause of patellar luxation is still not fully understood. There are indications that the condition is hereditary, as certain breeds such as Poodles, Yorkshire Terriers, Pomeranians, Chihuahuas, French Bulldogs, Pugs, and Jack Russell Terriers have a predisposition to it.[1, 7] While the dislocation may not be present

at birth, the anatomical deformities that cause the condition are already present at this time and are responsible for the subsequent recurrent patellar dislocation.[2] In addition, bilateral cases without trauma also indicate a congenital etiology. Patellar luxation is often associated with various irregularities in the conformation of the hip joint. These include unusual angles of inclination and anteversion, reduced coverage of the acetabulum and hip dysplasia. Other associated factors include torsion and angulation of the femur, deviation of the tibial plateau, tightness or atrophy of the quadriceps muscles, an elevated patella alta, and a shallow trochlear groove that is out of the normal range.[7, 8]

A valuable method for diagnosing and determining the appropriate surgical approach is to classify the degree of dislocation and body deformity.[2] Grade I patellar luxation in dogs is generally asymptomatic, with occasional limb bearing. The patella is easily dislocated by hand when the stifle is fully extended and returns to the trochlear groove when released, with no apparent crepitation. Grade II dislocation is more common than grade I dislocation and is characterized by occasional and mild signs of lameness. The patella dislocates easily, especially when the foot is rotated. It may dislocate completely, but manipulation of the hind limb is required to return it to its original position. Progression from grade II to grade III may occur due to erosion of the trochlear ridge, resulting in more severe clinical symptoms due to chronic degenerative joint changes. The patella may either dislocate spontaneously while the animal is standing, or it may be permanently dislocated but can be manually repositioned by manipulation of the limbs. Persistent lameness and abnormal posture are characteristic of grade III and IV patellar luxation. In grade IV, the patella remains dislocated, it is located just above the inner condyle and cannot be displaced. The limb may be carried, or the animal may move in a crouched position. The trochlea is flat, absent or convex, so chondroplasty is often required to create a new trochlea at a different angle so that it can be properly guided after transposition of the tuberositas.[1, 2, 9]

The symptoms of patellar luxation vary depending on the extent of the deformity, the duration of the condition, whether one or both stifle joints are affected and the age at which it begins.[10] Lameness indicators may vary and present as intermittent or continuous, often mild to moderate lameness on weight bearing with occasional limb bearing. Dogs with lateral luxation generally have more difficulty walking than dogs with medial luxation. Signs may worsen with weight gain, joint cartilage erosion, permanent luxation, cruciate ligament rupture or hip dislocation.[2] A thorough physical examination is essential to assess the severity of the dislocation and rule out additional factors that could

be contributing to hind limb lameness.[1] The examination considers factors such as instability in both directions, crepitus, degree of tibial rotation, limb deformity, the inability to reduce the patella, the position of the reduced patella within the trochlea, the inability to hold the limb at a normal angle, and the presence or absence of a cruciate ligament rupture, which provides important information for surgical planning.[10]

While the diagnosis of patellar dislocation is primarily made clinically, radiography plays a complementary role in confirming the diagnosis and assessing degenerative changes in the joint. It also helps to reveal existing bony deformities. Accurate positioning is crucial for reliable radiological examinations. Positioning can be difficult due to bone deformities or muscle contractures. Additionally, modern diagnostic imaging, such as CT scans, exceeds the limits of conventional radiology and offers 3D reconstructions that provide reliable images and measurements. Both X-ray images and CT scans allow the calculation of the anatomical and mechanical angles of the femur and tibia, making it easier to quantify deformities and plan surgical corrections.[1, 2, 10]

2.2 Different surgical techniques for managing patellar luxation

A patellar dislocation without recognizable symptoms is usually discovered during a routine examination. Immediate surgery is not recommended and is generally considered unnecessary. Instead, pet owners should watch for signs that may indicate problems, such as pushing the leg backwards, reluctance to jump and avoidance of intense exercise. Late surgical repair is still effective, even if an anterior crucial ligament tear occurs later.[2, 10]

The aim of surgical treatment is to realign the extensor apparatus, restore the normal biomechanics of the knee joint and stabilize the femoropatellar joint. Surgical procedures for stabilizing patellar dislocation can be divided into two categories. Such techniques can be categorized as bone and soft tissue reconstruction. Among the main bone reconstruction techniques are trochleoplasty (deepening of an abnormally flat femoral trochlea) and transposition of the tibial tuberosity. Soft tissue reconstruction techniques include exposure of the retinacular tissue (e.g. desmotomy, capsulectomy), overlapping or imbrication of the retinaculum and fascia, anti-rotation sutures and quadriceps release.[9, 10] Soft tissue techniques are often used in the treatment of patellar luxation in dogs, where the soft tissues around the patella are often either too tight or too loose.[1]

It is important to note that skeletal deformities should be corrected using bone reconstruction techniques, as the bony structures are the primary support structures of the patella. Most dogs undergoing surgery will require a combination of bony and soft tissue techniques, because long-term success will not be achieved by relying solely on soft tissue procedures.[1, 9]

One of the soft tissue techniques is the desmotomy. This involves releasing the soft tissue by making an incision in the retinaculum on the medial or lateral side of the joint, depending on the extent of the dislocation. In some cases, the incision can extend to the joint capsule.[1, 2] In contrast, lateral imbrication involves tightening the soft tissue on the side opposite the dislocation with sutures. This procedure is often performed in combination with a desmotomy.[9] [1, 11]

Anti-rotation sutures are similar to the extracapsular sutures used in cruciate ligament repair. A fabella-tibial suture can be placed from the lateral fabella to the tibial crest to cause external rotation of the tibia and move the tibial tuberosity further laterally.

Alternatively, a suture passed behind the fabella and around the patella can apply tension on the opposite side of the dislocation.[1, 2, 11, 12]

Most animals require a deepening of the trochlea. There are numerous methods to improve the depth of the trochlear groove, such as abrasion trochleoplasty, trochlear chondroplasty and wedge and block recession trochleoplasty. The aim of these procedures is to create a sufficiently deep and wide trochlear groove in which around 50% of the patella can be accommodated above the trochlear ridges. The most commonly used method is usually a trochlear wedge or block recession. [1, 2, 13]

Trochlear groove reduction is the deepening of the trochlea ossis femoris to stabilize the patella and maintain the integrity of the femoropatellar joint. In larger animals, an oscillating saw is often used for this purpose. In smaller breeds, however, the incisions in the trochlea can also be made with a fine-toothed handsaw or a scalpel blade and a hammer.[13] The trochlear wedge and block recession procedures are used to deepen the trochlear groove by removing an osteochondral autograft from the trochlear sulcus. Viewed in cross-section, this autograft can have a triangular (wedge) or rectangular (block) shape.[1] In the case of trochlear wedge deepening, the articular cartilage at the trochlea is cut in a diamond shape to remove a wedge of cartilage and bone. The width of the incision must be sufficient to accommodate the patella while retaining the rolling ridges. Additional bone is then removed from one or both sides of the newly formed groove to deepen it. If necessary, the wedge can be reshaped with a rongeur to fit properly into the new groove, and it can also be reimplanted and rotated 180 degrees if necessary. For the deepening of the trochlear block, a square incision is made. Care must be taken to ensure that the incision is sufficiently large and that the raised ridges are preserved. During block resection, an osteotome with a suitable width is used to lift the osteochondral segment. Similar to wedge resection, another section of bone is harvested from the base of the sulcus to achieve sufficient groove depth. After reinsertion and fixation, the wedge and block remain fixed by the compressive force exerted by the patella and the friction between the cancellous bone surfaces on both sides of the cut edge.[13]

A study in 2001 compared trochlear block resection and wedge resection for the treatment of canine patellar dislocation using a cadaver model. It was observed that resection of the block increases the depth of the proximal patella and improves its articular contact with the

recessed proximal trochlea by encompassing a larger surface area. This results in greater resistance to patellar dislocation with the knee extended compared to wedge resection.[4]

Transposition of the tibial tuberosity is a crucial aspect of the surgical procedure in dogs with patellar luxation, as misalignment of the quadriceps plays an important role in the development of this condition. The aim of this procedure is to reposition the attachment point of the tendon that runs between the patella and tibia. To do this, the bone to which the tendon is attached is cut and repositioned, as bones have a better healing capacity than tendons.[1, 2, 11]

To expose the tibial crest, a parapatellar approach is used from the side to gain access to the knee joint and the tibial muscle is elevated cranially. The osteotomy can then be performed with a hammer and osteotome or an oscillating saw blade, leaving only the distal attachment of the periosteum intact. The bone crest is then moved either medially or laterally, depending on the dislocation, until careful manipulation achieves central alignment of the patella in the trochlear groove.[1] The tibial tuberosity is repositioned and secured with one or two slender Kirschner wires placed downwards and slightly towards the direction of the body. The additional reinforcement of the tibial transposition can be achieved by using a cerclage as a wire sling, which is particularly recommended for larger dog breeds, but is occasionally also suitable for smaller dogs.[13]

After patellar luxation repair surgery, it is important to limit the patient's activities to specific physiotherapy exercises and controlled walks on a leash for 6 weeks.[13]

In the case of lateral patellar luxation, the prognosis for large dogs is less favorable than for small dogs with medial luxation. Overall, grade 1 to 3 luxation have a good prognosis. Postoperative recurrence of patellar luxation can occur in about 50% of joints, which is usually limited to grade 1 and does not affect clinical function. Patients with grade 4 dislocation should be treated with caution as they often require multiple procedures and in some cases corrective osteotomies may be required if reduction of the patella proves difficult.[13]

2.3 Risk factors of surgical site infection in orthopedic surgeries

Surgical site infections (SSI) remain a common cause of postoperative complications, resulting in significant morbidity and potentially serious consequences following surgery, despite ongoing advances in surgical techniques.[14] The severity of surgical site infections can vary, requiring different types of treatment. This may include extensive use of antimicrobial medications, frequent diagnostic tests and imaging, multiple surgeries, laboratory tests and other procedures that result in higher costs.[15] In addition, these challenges lead to an emotional and financial burden for animal owners and have a significant impact on animal welfare.[16]

Detection of surgical site infections requires analysis of clinical and laboratory results. A surveillance program must establish uniform and standardized definitions to calculate and report accurate SSI rates. Based on the Centers for Disease Control and Prevention´s (CDC) National Nosocomial Infection Surveillance System (NNIS), standardized surveillance criteria for the definition of SSI have been developed.[17] It is reasonable to apply these criteria in veterinary medicine as well, and it is essential to use an impartial definition when assessing SSI.[18]

Surgical site infections are categorized as incisional, or organ/space infections based on specific criteria. SSIs at the incision site can be classified as either superficial, which involves only the skin and subcutaneous tissue, or deep, involving the deeper soft tissues of the incision site. In contrast, Organ/Space SSIs include all parts of the body other than the layers of the incision site that were opened or manipulated during surgery.[17]

The criteria for a superficial surgical site infection are that it occurs within 30 days of the surgical procedure, involves only the skin and subcutaneous tissue, and either has purulent drainage from the incision site or organisms are detected in a culture-based test sample obtained from the superficial incision for clinical diagnosis or treatment purposes. In addition, signs such as localized pain/painfulness, swelling, redness and heat are indicative of an SSI.[17, 19, 20]

For deep incision SSI, the classification requirement includes events that occur within 30 to 90 days of surgery and are limited to deep soft tissues such as fascial and muscle layers, as well as symptoms such as purulent discharge from deep incisions and identification of the organism by microbiologic testing methods for clinical diagnosis. Signs such as fever

(>38°C) and localized pain/sensitivity also contribute to this type of infection identification.[19, 20]

And finally, Organ/Space SSI refers to an infection that occurs within 30 days of surgery without the presence of an implant, or within one year if an implant is present and the infection appears to be related to the surgery. The infection involves a part of the anatomy other than the incision that was opened or manipulated during the procedure. In addition, one of the following conditions must be met. Either purulent discharge from a drain inserted into the organ/space must be present, or organisms can be identified from a culture obtained under sterile conditions, or an abscess or other evidence of infection is present as determined by direct examination, reoperation, histopathologic examination, or radiologic examination. In addition, in all cases of SSI, the diagnosis must be made by a surgeon or attending physician.[17]

It is a challenge to find accurate data on the prevalence of SSI rates in small animal orthopedic procedures. Several veterinary research studies have documented SSI rates that include both general and procedure-specific infections. However, these studies are often limited by inadequate SSI definitions, lack of appropriate prospective surveillance programs, and relatively small sample sizes. In retrospective studies, many infections, particularly superficial ones, may not be reported if they are treated by other veterinarians or not recorded in the surgical facility. Therefore, retrospective studies are likely to underestimate actual SSI rates.[16] In the veterinary literature, the rates of surgical site infections in animals undergoing clean surgical procedures range from 3.6% to 5.8%.[18, 21, 22] Orthopedic and neurosurgical procedures in dogs were found to have SSI rates between 0.6% and 7.1%. However, there are notable differences between the procedures, in the case of TPLO surgery, for example, higher SSI rates of up to 21.3% have been documented.[23, 24] (Table 1)

Table 1. Incidence of surgical site infections in orthopedic procedures within the field of veterinary medicine

Species	Number of surgical procedures	Surgical procedure(s)	SSI incidence (%)	Reference
Dog	221	Total hip replacement	7.7%	[25]
Dog	77	Cemented total hip replacement	1.3 %	[26]
Dog	101	Tibial tuberosity advancement	2.6 %	[27]
Dog	200	Elective joint surgery	3.5 %	[28]
Dog	83	Tibia plateau leveling osteotomy (TPLO)	3.6 %	[21]
Dog	1146	TPLO	6.6%	[29]
Dog	226	TPLO	13.3 %	[30]
Dog	208	TPLO	21.3%	[31]
Dog	112	Clean orthopedic procedures	7.1 %	[32]

Several risk factors have been identified in orthopedic surgery in veterinary medicine that are associated with the development of surgical site infections.[33] The occurrence of infections at the surgical site is directly related to various factors before, during and after the operation.[34, 35]

Preoperative factors such as age, gender, race, nutritional status, endocrinopathy, use of immunosuppressants, presence of infection at a distant site, hypoalbuminemia, American Society of Anesthesiologists (ASA) physical status (Table 2), colonization of the skin with microorganisms, especially Staphylococcus aureus, and inappropriate use of prophylactic antimicrobials all contribute to the risk of surgical site infections. There is a higher risk of infection in young and older dogs and in intact male dogs. High levels of androgens can contribute to this increased risk.[14, 16, 20, 35] Breed can also play a role in the likelihood of surgical site infections, with Labrador Retrievers having a lower risk compared to other breeds.[29] Both malnutrition and obesity increase the likelihood of SSI while animals with conditions such as diabetes mellitus, hyperadrenocorticism and hyperthyroidism also have an 8.2-fold higher risk of infection. In addition, immunosuppressive drugs and remote

infections compromise the immune system, making dogs more likely to develop an infection.[16, 35–38] Hypoalbuminemia can have an impact on immune function as well and therefore also increases the risk of infection.[39] Moreover, the higher the ASA score, the greater the risk of the patient getting an infection.[22, 35] Inappropriate use of prophylactic antimicrobials, such as the wrong type, dosage or timing, can also lead to an increased risk of SSI in dogs.[37]

Table 2. American Society of Anesthesiology (ASA) physical status classification system

ASA 1	A normal, healthy patient
ASA 2	A patient with mild systemic disease
ASA 3	A patient with severe systemic disease
ASA 4	A patient with severe systemic disease that is a constant threat to life
ASA 5	A moribund patient who is not expected to survive without the operation
ASA 6	A declared brain-dead patient whose organs are being removed for donor purposes

Note: reprinted from The ASA classification and peri-operative risk, by Fitz-Henry J, 1993 [40]

Perioperative factors also have a significant impact on the risk of surgical site infection (SSI). Hypotension during surgery can increase this risk up to 27-fold, as can systemic hypoxia, which affects the oxygen supply to the wound, which is crucial for healing.[20] The likelihood of SSI is increased by three times in patients with mild to severe perioperative hypothermia.[38, 41] Improper sterilization of medical devices increases the risk, as do inappropriate hair removal methods, such as removing hair before induction, and the use of shavers instead of clippers, there is also an influence of inadequate skin antisepsis on the risk of SSI.[35, 37]

Furthermore, each additional person in the operating room correlates with a 1.3-fold increase in the risk of SSI.[22] In addition, increased staff traffic is a source of bacteria from the air movement due to the opening and closing of the operating theater door, as well as from the skin and respiratory tract of the surgical team.[42] Surgeon experience also has an impact, with less experienced surgeons being associated with higher SSI rates.[23, 35, 43] Dogs receiving a Implanted medical Device (IMD) the risk of developing a SSI is 5.6-fold higher than in dogs with no IMD. Additionally, a longer duration of anesthesia and surgery increases the risk due to immunosuppression and tissue

dehydration. For every additional minute of surgery and anesthesia, the risk of surgical site infection increased by 30 percent. In addition, older studies described that postoperative wound infection was increased 3.8-fold when animals were anesthetized with propofol. The explanation for this is probably that propofol can be easily contaminated, especially if one vial is used for several patients.[20, 36, 44]

Besides pre- and perioperative factors, postoperative factors also play a significant role in determining the risk of surgical site infections (SSI). Firstly, a longer hospital stay both before and after surgery has been found to correlate with a higher risk of SSI.[22, 36]. Also, while drains are intended to reduce the accumulation of bacteria, they can paradoxically serve as a route of infection if not handled properly.[22, 35, 38]

2.4 Current practices regarding antibiotic prophylactics in orthopedics in general

Prophylactic administration of antibiotics is just one of several strategies to minimize the incidence of surgical site infections, which is the most prevalent nosocomial infection in patients that undergo surgery.[45] Other methods to reduce the possibility of SSI include adequate preparation of patients and surgical teams as well as careful consideration of surgical techniques and intraoperative measures together with monitoring of patients' physiological parameters.[46] Nevertheless, inappropriate antibiotic prophylaxis, such as incorrect dosing and broad-spectrum antimicrobials, has been proven many times to lead to antimicrobial resistance, superinfection and unnecessary costs.[45]

Inadequate use of antimicrobials in both animals and humans globally have been associated with the increase in antimicrobial resistance in humans, animals, and their environment, posing a major public health challenge worldwide. The understanding and perspective of veterinarians regarding antibiotic resistance plays an important role and can influence the occurrence of antibiotic-resistant bacteria. Therefore, the veterinarian needs to understand current practices regarding the use of antibiotics in surgical procedures such as patellar luxation, especially because the role of companion animals in the spread of antibiotic resistance has not been as thoroughly studied as that of farm animals. Small animals that live near humans and frequently receive antimicrobial treatments, including those used in human medicine, could serve as reservoirs for antimicrobial-resistant bacteria such as methicillin-resistant Staphylococcus aureus or Vancomycin-resistant enterococci, which present a risk for zoonotic transmission. This is particularly true when broad-spectrum agents such as aminopenicillins plus clavulanic acid, cephalosporins and fluoroquinolones are used on a large scale.[47, 48]

In veterinary medicine, there is a limited body of research evaluating the pros and cons of antibiotic prophylaxis due to restrictions such as specific surgical procedures, small sample sizes, variable use of antibiotics, varying definitions of surgical site infections, and retrospective perspectives. In general, results are inconsistent.[16, 22, 39] Therefore, more conclusive evidence for or against the use of antimicrobial prophylaxis in clean surgery is needed, especially considering the alerting increase in antimicrobial resistance.[24]

Pre-operative antibiotic prophylaxis is frequently administered in both human and veterinary medicine. The National Institute for Health and Care Excellence in the UK

recommends the administration of antibiotics to patients before clean operations involving prostheses or implants, as well as before clean-contaminated or contaminated surgery. Nonetheless, NICE does not recommend routine prophylaxis for clean non-prosthetic procedures.[49] Based on a 2017 report from the Centers for Disease Control, antimicrobial prophylaxis should only be administered in accordance with specific clinical guidelines.[50] While there have been local clinical guidelines for certain human procedures, the current veterinary literature contains several antibiotic guidelines but no evidence-based recommendations for specific clinical practice.[46, 51]

The use of a prophylactic antimicrobial agent should be selected based on the organisms most likely to cause wound infection. Selection criteria should include the level of contamination, the nature and complexity of the procedure, knowledge of local resistance patterns and regulatory considerations such as local antimicrobial guidelines and legislation.[14] The Danish Antibiotic Use Guidelines for Companion Animal Practice emphasize that perioperative antibiotic prophylaxis should not be a replacement for a thorough aseptic surgical technique. It should only be used after assessing the patient status, type of procedure and wound classification. (Table 3) In general, low-risk patients (ASA 1-2) who undergo clean procedures and apyretic ASA 3 patients that are having clean or clean-contaminated procedures do not require antibiotic prophylaxis. High-risk patients including ASA 3 with contaminated or infected wounds, patients with purulent infections, pyretic patients and ASA 4-5 require perioperative antibiotics. Additionally, in cases where surgical site infection would have serious consequences, including orthopedic implants and CNS surgery, perioperative antibiotics are also recommended.[52, 53]

Table 3. Classification grades for surgical wounds as defined by the Centers of Disease Control and Prevention (CDC)

Classification	Description	Prophylactic antibiotic treatment	References
Clean	A non-infected surgical incision that does not show any signs of inflammation, and does not involve the respiratory, digestive, reproductive, or uninfected urinary system. Clean wounds are primarily closed and may be drained using closed drainage if needed.	Prophylactic antibiotics are not recommended.	[20, 54, 55]

Clean-Contaminated	A surgical incision where access to the respiratory, digestive, reproductive, or urinary tracts is performed under controlled conditions and without significant contamination. This category includes procedures on the biliary system, appendix, vagina, and oropharynx as long as there is no evidence of infection or major breach of sterility protocol.	Prophylactic antibiotic administration may be considered appropriate for surgical procedures expected to exceed one and a half to two hours.	[20, 54, 55]
Contaminated	Open, fresh injuries that are unintentional. In addition, procedures with significant fractures where the aseptic technique was not followed or extensive excretions from the digestive tract as well as surgical incisions where a sudden or no purulent inflammation occurs fall under this classification.	Antibiotic prophylaxis may be necessary when there is a substantial risk of infection. Fresh wounds that are managed using standard surgical protocols usually do not require antibiotic treatment.	[20, 54, 55]
Dirty	Traumatic injuries that have old retained damaged tissue and those involving current clinical infection or perforated internal organs. This description implies that the bacteria responsible for infections after surgery were already present in the surgical area before the procedure. For instance, this is relevant to older bite injuries with significant damage to the soft tissue or traumatic open fractures	Antibiotic therapy is given in such situations.	[20, 54, 55]

Note: Adapted from Surgical Wound Classification, Centers for Disease Control and Prevention

The guidelines also underline the crucial importance of the correct use of antibiotics. When using antibiotics, it is essential to choose those with a narrow spectrum that target the bacteria expected in the area to be operated on. In orthopedic surgery, the most common microorganisms responsible for wound infections typically originate from the skin flora, particularly staphylococci, streptococci and corynebacteria. Therefore, cefazolin and related first-generation cephalosporins, administered preoperatively at four-hour intervals until completion of surgery, remain the standard for orthopedic prophylaxis. They should also penetrate the tissue effectively and be administered intravenously at least 30 minutes before the incision, but not more than 60 minutes, to ensure sufficient concentration during

the operation. Prolonged surgery may require re-administration, but the goal is to discontinue prophylactic use after the procedure is complete. It is important to note that prolonged administration after surgery does not reduce the risk of infection but worsens side effects and increases bacterial resistance. Nevertheless, in cases such as contaminated and dirty surgery, antibiotics should generally be continued after surgery to treat the infection.[14, 16, 53, 56]

According to the Swedish Veterinary Association's guidelines, prophylactic antibiotics are also only prescribed if there is a high probability of surgical complications or if an infection could have serious consequences, such as in hip replacement surgery. In addition, antibiotic prophylaxis may also be considered for prolonged operations lasting more than 90 minutes and for procedures on high-risk patients. However, it should be noted that the use of surgical implants such as plates, screws or pins in cases such as fractures, corrective surgery and TPLO or TTA does not automatically require prophylactic antibiotic treatment.[14, 55] Orthopedic procedures that in any case require perioperative antibiotic prophylaxis are total hip joint arthroplasty, open fracture surgery and complex fracture treatment.[20] In all other cases, it depends on the respective circumstances and working conditions.

3. Material and Method

The objective of our study is to prove that peri – and postoperative prophylactic antibiotics are not necessary in relation to patella luxation surgery by reviewing the infection rate from the patients in this retrospective study. Furthermore, we would like to get an overview of the overall satisfaction of the owners after patella luxation surgery from these particular cases and how they evaluate the healing process based on their own experience.

3.1 Study design

The study comprises a retrospective analysis of 122 dogs that had undergone a patella luxation surgery between the period of April 2019 to December 2023. The patient pool consisted of dogs operated on by Dr. med. vet. Nicola Katic, Dipl. ECVS, either as a consulting veterinarian in different clinics around Austria or from August 2021 onwards, in his own practice, "Fachtierärzte Althangrund.". Out of these 122 cases, we were able to get a follow-up of 101 cases, which were subsequently divided into two groups for further investigation., one main and another additional smaller group. For the main group the prerequisites for inclusion in the study were dogs that had undergone patellar luxation surgery without perioperative or postoperative prophylactic antibiotics during the above-mentioned period and had a known postoperative follow-up of at least 6 weeks. Follow-up was either known from the clinic data or from a completed questionnaire given to the owners. In addition, the dogs with a concurrent cranial cruciate ligament rupture operation had to be excluded, as the operation itself is different and both the operation time and the risk of infection are higher than in those of patellar luxation surgery. In the secondary smaller group, dogs with concurrent cranial cruciate ligament rupture were included in order to determine a separate SSI rate of dogs undergoing a patella luxation and a concurrent cranial ligament rupture surgery.

3.2 Data collection

A multi-method approach was used in this study, involving the collection and analysis of quantitative and qualitative data. In the first part of the study, we collected data from the electronic medical records of Provetcloud by “Fachtierärzte Althangrund”. All patients were included which have been found in the system under the category: correction of patella luxation by means of block recession and displacement of the tibial tuberosity <10kg, 10-30kg and >30kg. Information collected from this platform was the data from the

owners, the signalment of the patients, such as breed, sex, bodyweight, age, and age at the time of the surgery. The anesthesia time was documented, as well as the administration of perioperative or postoperative prophylactic antibiotics. Furthermore, follow-up visits, treatment of SSI and whether the operation took place in the practice "Fachtierärzte Althangrund" or was done as a consultant veterinarian was recorded. In addition, it was documented if a concurrent cranial cruciate ligament rupture was diagnosed and operated on either by means of a tibial plateau leveling osteotomy or an extracapsular lateral suture stabilization. All this information was accurately collected and documented using Microsoft excel 365 MSO (Version 2402). In the second part of the study, all owners received an online questionnaire, which was created with the internet program "SoSci Survey" (Leiner 2024). The link was sent to the owners by email. The questionnaire was written in German and only fully completed questionnaires were statistically analyzed. The data was evaluated anonymously using Microsoft excel 365 MSO (Version 2402). The following questions were asked in the questionnaire. (Table 4)

Table 4. Survey questions with possible answers.

Questions	**Possible answers**
Are you satisfied with the outcome of the surgery, and would you do it again?	a. Very satisfied b. Satisfied c. Less satisfied
Did the dog lick the wound after the operation?	a. Yes b. No
Were prophylactic antibiotics prescribed by your veterinarian after the surgery?	a. Yes b. No c. I don´t know
Did the dog show any swelling and redness at the wound site after the operation?	a. Yes, clearly recognizable. b. Mild redness and swelling c. No
Were antibiotics administered to the dog after the operation for the swelling and redness?	a. Yes b. No c. I don´t know
Was the implant removed from the dog at a later time?	a. Yes b. No

How was the dog after the surgery? Did he/she show any general problems (fever, inappetence etc.)?	a. If yes, which... b. No
How severe was the dog´s lameness after the surgery?	a. 1 – Mild b. 2 – Mild to moderate c. 3 – Moderate d. 4 – Moderate to high e. 5 – High degree
When was the point when the lameness completely went away?	a. After 2 weeks b. After 4 weeks c. After 6 weeks d. After … weeks

In relation to the determination of the infection of the surgical site, the CDC guidelines were followed in setting the definition of SSI. If signs of SSI such as localized pain, swelling, and additional incision drainage occurred or a bacterial culture of the surgical site was obtained, the dog was considered to have a surgical site infection. In the event that no abnormalities were found in the patient file during the postoperative follow-up examination or according to the information provided by the owners in the questionnaire, the surgical site was classified as not infected.

3.3 Statistical analysis

Each questionnaire was coded to detect errors and inaccuracies in the data entry. Analysis of the data was carried out using Microsoft Excel 365 MSO (Version 2402). Apart from descriptive statistics, a Chi-squared test [57] was performed to determine whether there was a significant difference between the group that received postoperative prophylactic antibiotics and the other group that did not receive any prophylactic antibiotics. The level of p-level was set to 0.05.

4. Results

4.1 Descriptive statistics

In this retrospective study, 122 dogs have been investigated. Out of these, 71/122 (58.2%) were female of which 49/71 (69.01%) were neutered and 51/122 (41.8%) were male out of which 16/51 (31.37%) were neutered. The mean±SD age of the animals at the time of the operation was 4,20 ± 3,08 years. The youngest animal was 5 months old, and the oldest animal was 12 years old.

A total of 23 different breeds were included, the most common breed was in any case the Chihuahua (29), followed by Crossbreeds (26), Yorkshire Terriers (15) and Pomeranians (12). The mean±SD weight was 6,42 ± 5,95 kg, the minimum weight was 1.8 kg, and the maximum weight of a dog was 54 kg.

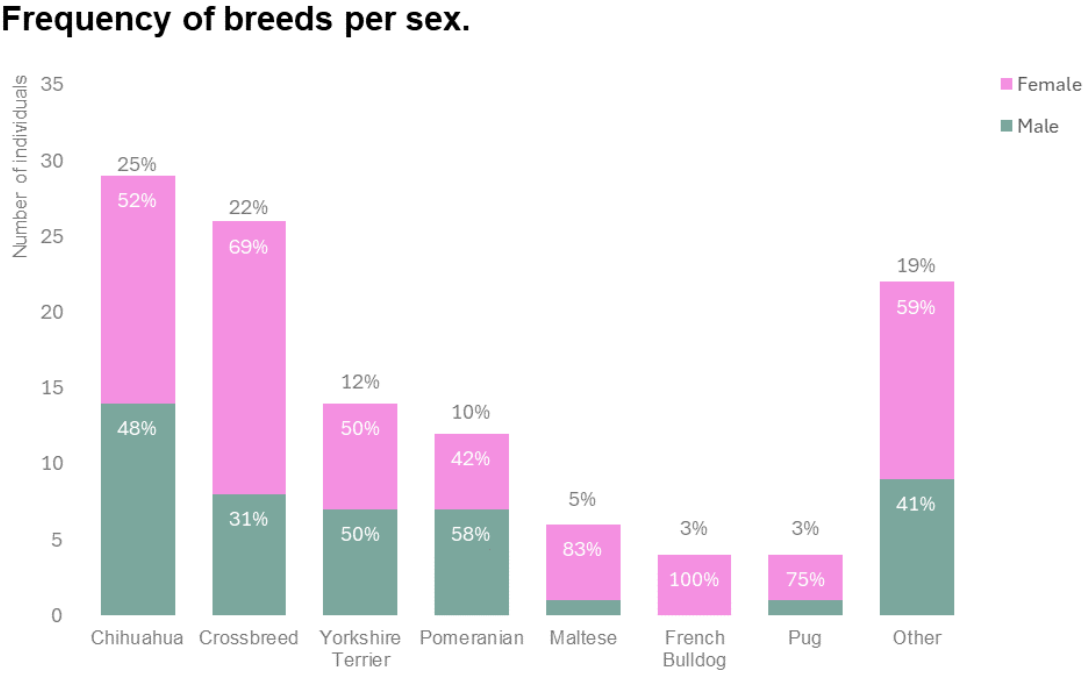

Figure 1. Breed distribution per sex (n=122). The percentage inside the bars refer to relative number of female and male within a certain breed. The percentage above the bar refer to the relative number of the breed. Reading example: 10% of all dogs were Pomeranian. 58% of all Pomeranian were male and 42% were female.

Of the 122 operations, 68/122 (55.74%) were conducted at the "Fachtierärzte Althangrund" practice and 54/122 (44.26%) were done as a consulting veterinarian at various practices. A total of 16/122 (13.11%) had a concurrent cranial cruciate ligament rupture operation in addition to the patella luxation operation. None of the 122 cases involved dogs receiving peri- or postoperative prophylactic antibiotics from the surgical team.

We have a postoperative follow-up of at least 6 weeks from 101/122 (82.79%) dogs. Among these follow-up cases, a total of 13/101 (12.87%) had concurrent cranial cruciate ligament rupture surgery, out of which 8/13 (61.54%) had a tibial plateau leveling osteotomy (TPLO) and 5/13 (38.46%) an extracapsular lateral suture stabilization. In addition, 12/101 (11.88%) received postoperative prophylactic antibiotics from the referring veterinarian.

We divided these follow-up cases into two groups: a main group and an additional smaller group for further analysis.

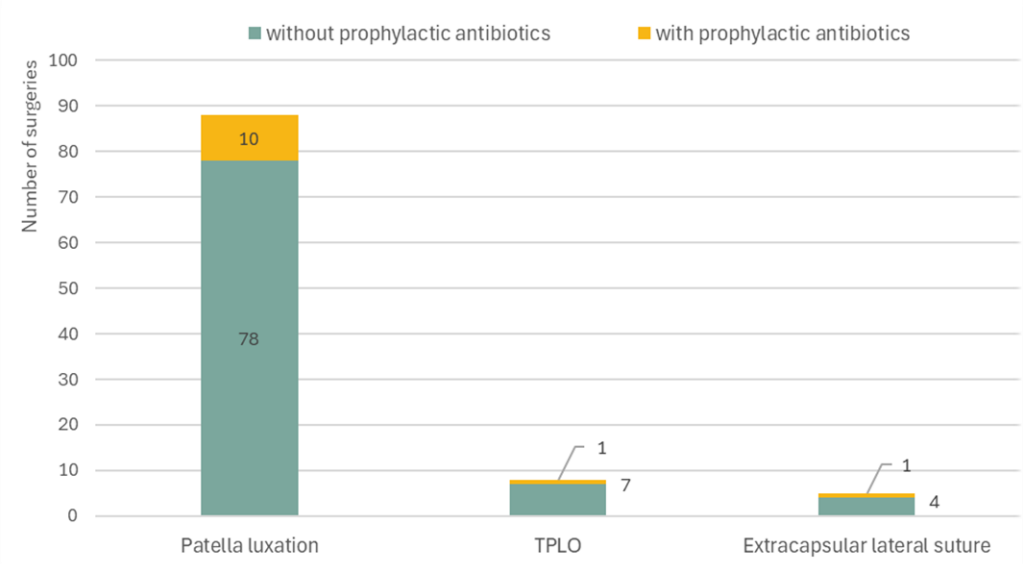

Figure 2. The incidence of postoperative prophylactic antibiotic use in the different operational categories (n=101)

4.2 Incidence of surgical site infection after patella luxation surgery

For the main group, only dogs with follow-up information of at least 6-weeks, without peri-or postoperative prophylactic antibiotic administration and without concurrent cranial cruciate ligament repair were included. This leaves a total of 78/122 (63.39%) for the further analysis of the occurrence of SSI in patella luxation surgery solely without prophylactic antibiotics in any case. Mean follow up time was 671 days (range 55-1754). SSI was diagnosed in 2/78 dogs (2.56%), in both cases a superficial/deep surgical site infection was detected. One infection was diagnosed 14 days after the operation and the other one 20 days after the operation, in both cases the infection occurred after the stitches were removed and both dogs had been licking their wounds according to the owners. In addition, both dogs received Cefalexin 20 mg/kg (Therios) to treat the infection.

The mean±SD anesthesia time, including induction and timing of surgery, for patellar luxation surgery was 122.55 ± 21.36 minutes, although we had no information on the anesthesia time in the case of 25/78 (32.05%) dogs.

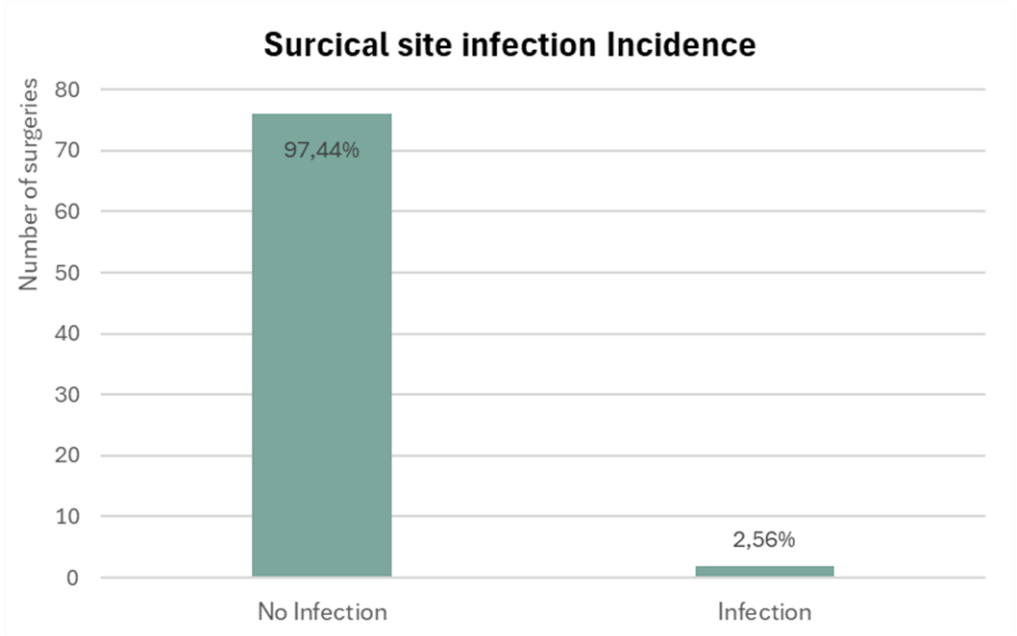

Figure 2. Incidence of surgical site infection in Patella luxation surgery without peri- or postoperative prophylactic application of antimicrobials (n=78)

4.3 Incidence of surgical site infection after patella luxation surgery with concurrent cranial cruciate ligament repair

A total of 16/122 (13.11%) had a concurrent cranial cruciate ligament rupture operation in addition to the patella luxation operation, out of which 8/16 (50%) had a tibial plateau leveling osteotomy (TPLO) and 8/16 (50%) had an extracapsular lateral suture stabilization. We had a follow up of 13/16 (81.25%), leaving a total of 13/122 (10.66%) for the small additional group. Out of these, 2/13 cases (15.38%) received postoperative prophylactic antibiotics from the referring veterinarian. From the 11 cases in which neither perioperative nor postoperative prophylactic antibiotics were administered, no surgical site infection could be detected.

The mean±SD anesthesia time, including induction and timing of surgery, for patellar luxation surgery with concurrent cranial cruciate ligament rupture repair was 137.5 ± 52.42 minutes

4.4 Correlation between SSI incidence with and without prophylactic antibiotics within the main group

There was a follow-up of 88 out of a total of 122 cases, which had a patella luxation surgery solely. 10/88 (11.63%) received prophylactic antibiotics from the referring vet after surgery. To evaluate the correlation between the group without peri- and postoperative prophylactic antibiotics (n=78) and the group with postoperative prophylactic antibiotics (n=10) a chi-square test was used. In this case, we investigated the occurrence of infections concerning the administration of postoperative prophylactic antibiotics versus the absence of any prophylactic antibiotic treatment.

The statistical analysis revealed no significant difference in the incidence of surgical site infections between dogs receiving prophylactic antibiotics and those not. The chi-square test provided a p-value of 0.683, greater than the common significance level of 0.05, suggesting that the observed differences are likely due to chance. In other words, the probability of the observed differences occurring due to chance alone is high. Therefore, due to the high p-value, no statistically significant difference can be found between the administration of prophylactic antibiotics and the risk of infection.

4.5 Evaluation of the questionnaire

Among the 122 cases that were collected, 101/122 (82.79%) of the owners fully completed the questionnaire that was sent to them. According to the question "Are you satisfied with the outcome of the surgery, and would you do it again?", the majority 66/101 (65.35%) was very satisfied, the other part 25/101 (24.75%) was satisfied and 10/101 (9.90%) were less satisfied.

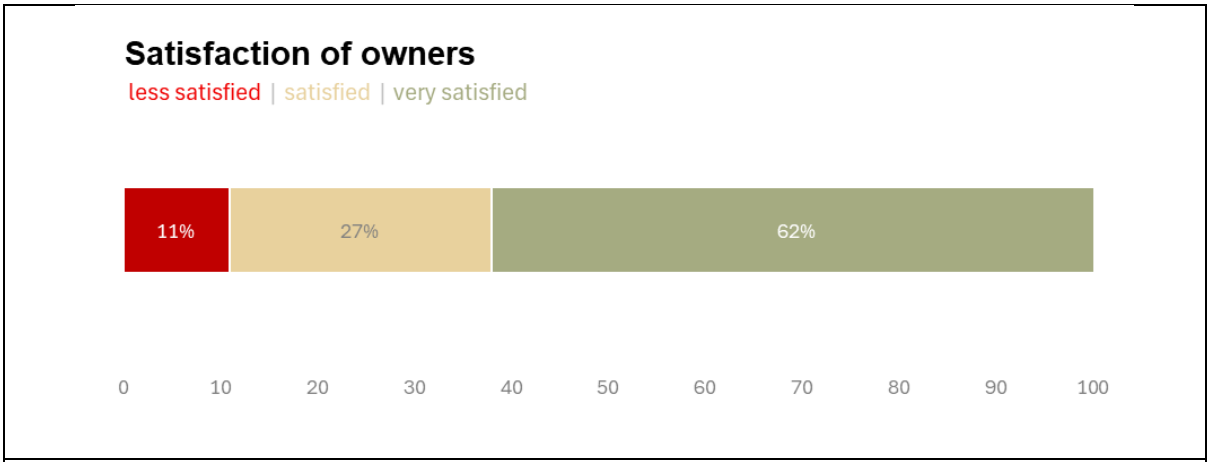

Figure 4. Satisfaction of the owners (n=101).

In response to the question of whether the dog had licked the wound, 14/122 (13.86%) answered yes, while most 87/122 (86.14%) answered no. In addition, 4/101 (3.96%) said that they clearly saw redness and swelling when asked if their dog showed swelling or erythema on the wound after surgery. The other owners 18/101 (17.82%) either stated that they saw mild redness and swelling or that 79/100 (78.22%) did not see any changes.

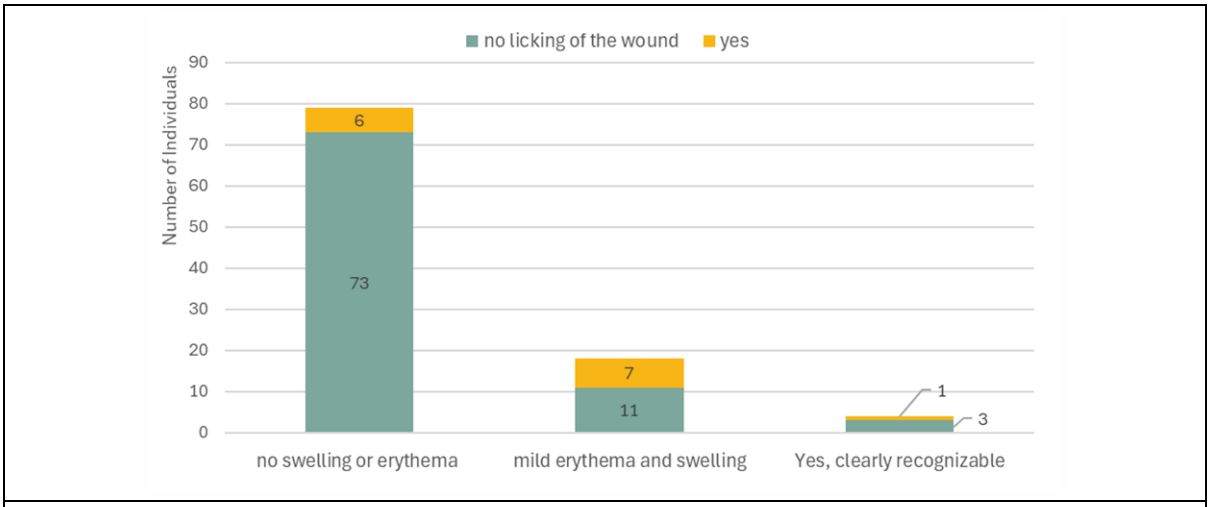

Figure 5. Correlation between licking and condition of the wound according to the dog owner (n=122)

A total of 18/101 (17.82%) owner stated that the pin required for the operation had been removed at a later date. In addition, owners were asked if they had noticed that their dog had any problems in general after the operation, such as fever or inappetence. Out of these, 85/101 (84.16%) stated that they had not noticed any problems, while the remaining 16/101 (15.84%) dogs had problems of various kinds after the operation, like loss of appetite, lethargy, pancreatitis, and gastroenteritis.

Regarding the perception of lameness, patients were asked how much they noticed the dogs' lameness after surgery. 18/101 (17.82%) reported that the lameness was mild, 30/101 (29.70%) responded that the lameness was mild to moderate, for 25/101 (24.75%) the lameness was moderate, 21/101 (20.79%) stated that the lameness was moderate to high and 7/101 (6.93%) perceived the lameness as severe.

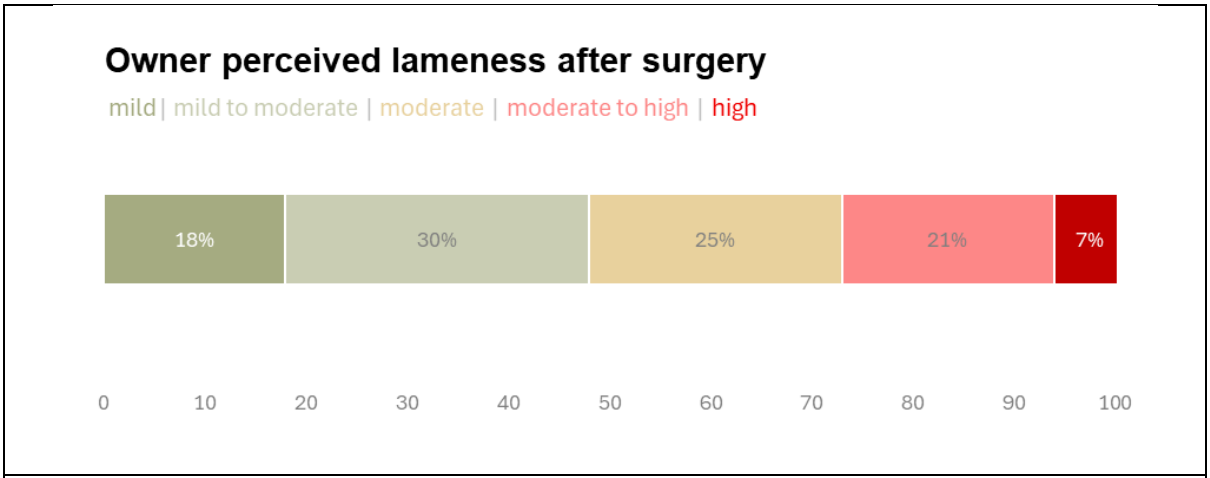

Figure 6. Assessment of lameness after surgery (n=101)

Owners stated that on a mean±SD 5.31 ± 4.09 weeks the dog's lameness had completely disappeared. The minimum of the reported dates was 1 week, and the maximum was 26 weeks. In addition, 8/101 (7.92%) owners stated that their dog still suffered from lameness from time to time.

5. Discussion

The findings of this retrospective study investigate the necessity of peri- and postoperative prophylactic antibiotics in relation to patella luxation surgery in dogs by evaluating the infection rate after surgery and the overall satisfaction of the owners regarding the post-operative recovery of the patients. By analyzing both quantitative data from medical records and qualitative data from owner surveys, we aimed to provide a comprehensive insight into the outcomes of patellar luxation surgery.

The descriptive statistics demonstrate the most significant demographic characteristics of the study population. The majority of dogs examined were female, with Chihuahuas being the most commonly affected dog breed, followed by Crossbreeds, Yorkshire Terriers and Pomeranians. These results are consistent with the existing literature suggesting a predisposition of small dog breeds to patellar luxation. In addition, the average age and weight of the animals emphasize the prevalence of this condition in relatively young and lightweight dogs.[1, 7] We also found that 13.11% of our examined cases suffered from a concurrent rupture of the cranial cruciate ligament and therefore we can confirm this statement as mentioned in the literature that 15% to 20% of dogs suffering from chronic patellar luxation develop a concurrent rupture of the cranial cruciate ligament.[2, 6]

For further analysis of our study, we divided the follow ups cases that did not receive perioperative or postoperative antibiotics into two groups to clarify surgical site infection (SSI) rates as precisely as possible in relation to the types of surgeries performed. The main group, containing the majority of cases, consisted of dogs undergoing patellar luxation surgery solely, while the secondary smaller group included dogs undergoing both patellar luxation surgery and an additional cranial cruciate ligament rupture operation. We decided to divide these cases into two groups because dogs with an additional cruciate ligament rupture underwent an additional operation, leading to the selection of different implants and longer anesthesia time. Therefore, the main focus was placed on the primary group to define a homogeneous cohort. However, we also wanted to describe the small additional group to provide an overview of all the collected cases.

In the main group, including dogs undergoing patellar luxation surgery with a comprehensive postoperative follow-up and without the administration of intraoperative or postoperative prophylactic antibiotics, the incidence of surgical site infection (SSI) was

2.56%. According to research published on the appropriate use of antimicrobial prophylaxis in clean orthopedic and neurosurgical procedures in dogs, the incidence of surgical site infections after patella luxation surgery was 5.4% despite the use of perioperative prophylactic antibiotics.[24] Compared to our study, we can be reasonably satisfied with our results, even though there are no other published data on surgical site infection in the particular procedure, which are comparable. Both cases of SSI in our study were categorized as superficial/deep infections and occurred within three weeks of surgery after suture removal. Additional both infected dogs were reported to have licked their wounds, indicating a possible behavioral factor contributing to postoperative complications. In addition, the infections were effectively treated by the administration of Cefazolin, which is the recommended antimicrobial in orthopedic surgery according to the literature. [14, 17] Our data did not provide anesthesia related risk factors that may contribute to the development of SSI, which have been mentioned in various literatures, as we unfortunately had a limited amount of data available.[20, 36] However, given the increasing concern over antimicrobial resistance, it is crucial to be mindful of the risk factors that can influence the rate of surgical site infections (SSI). Following strict aseptic procedures, maintaining proper surgical techniques, providing balanced anesthesia, and ensuring careful SSI monitoring are key factors in SSI prevention that cannot be replaced by the use of prophylactic antibiotics.[24]

In the additional smaller follow-up group without peri- or postoperative prophylactic antibiotics, including dogs with patellar luxation and an additional cranial cruciate ligament operation (TPLO or extracapsular lateral suture stabilization), we did not observe any SSIs, which is very satisfactory. However, this statement lacks significance because the group size is way too small. Nonetheless, we wanted to mention it despite the small sample size, as it hopefully encourages further studies with larger cohorts and proper study analysis in this area of different orthopedic procedures.

It was noticeable that of all follow up cases we collected, 11.88% received prophylactic antibiotics postoperatively from the vet who referred them for surgery, with no evidence of surgical site infection. This in turn reflects the fact that unfortunately many vets still prefer to give antibiotics prophylactically, even though it is not necessary, in order to make sure that no infection develops. However, this allowed us to compare the groups receiving prophylactic antibiotics and those who did not within the main group. Our study findings revealed that administering prophylactic antibiotics post patellar luxation surgeries in dogs

did not significantly affect infection rates and that it is plausible that other aspects such as surgical technique, postoperative care, or individual patient-specific factors might play a more substantial role in infection prevention than antibiotic administration, at least in the context examined. This could have significant implications for clinical practice by reducing unnecessary antibiotic exposure and the risk of antibiotic resistance. Nevertheless, this retrospective study revealed that the administration of antibiotics did not significantly affect the overall, already quite low, incidence rate of surgical site infections (SSI). However, due to the limited sample size, the test had low statistical power, particularly given the low incidence rate of SSI. Consequently, the results only suggest that antibiotic administration may not have been necessary. Further studies involving a larger number of cases in both groups are necessary to obtain a more statistically significant conclusion.

It's also noteworthy to highlight that 55.74% of the surgeries were conducted at “Fachtierärzte Althangrund”, where a standardized septic protocol was consistently adhered to. However, 44.26% of the surgeries were performed in various clinics across Austria, each with its own septic protocols. According to that, it can be concluded that the occurrence of a surgical site infection (SSI) is not solely dependent on the location of the procedure.

Additionally, the evaluation of owner satisfaction provided valuable insights into the subjective experiences following surgery. The majority of owners reported high levels of satisfaction with the outcomes, indicating positive experience of the surgical intervention. The low incidence of post-operative complications such as lameness and general problems, further contributes to the favorable perception of the procedure among owners. An interesting observation was that 3.96% of owners reported seeing significant redness and swelling at the surgical site, while 17.82% reported seeing mild redness. However, these cases were not identified as SSI in our study, as they were purely based on the owner’s subjective perception. As described in the literature, according to the standardized surveillance criteria of the Centers for Disease Control and Prevention (CDC) for the definition of SSI, the diagnosis must be made by a surgeon or attending physician in all cases.[17]

The owners reported that the dog's lameness was completely resolved after an average of 5.3 weeks, providing a useful guideline for clinicians to predict the postoperative course of

the patient. Nevertheless, the owner's statements about the severity of the lameness post-surgery and the time of complete disappearance of the lameness should also be treated with caution, as this is a purely subjective perception of the owners. In some cases, the surgery may have occurred several years ago, which is why some owners may not remember the grade of lameness anymore.

Furthermore, it is important to recognize the limitations of our study, including its retrospective nature and reliance on owner-reported data, which may have led to potential selection bias. Future prospective studies with larger sample sizes and control groups are required to validate our findings and provide solid evidence for the prophylactic use of antibiotics in patellar luxation surgery. However, not only patellar luxation surgery, but also other orthopedic surgeries require further investigation, as there are not many literature studies available. In particular, studies must be carried out in which groups that have received peri- or postoperative prophylactic antibiotics are compared with groups that did not receive them.

In conclusion, our study suggests that peri- and postoperative prophylactic antibiotics may not be necessary in patella luxation surgeries, as they did not significantly impact infection rates in this cohort study of 101 dogs. Additionally, the low incidence of SSIs and high levels of owner satisfaction underscore the efficacy of surgical intervention in managing patella luxation in dogs.

6. Summary

Orthopedic surgery in dogs often involves the risk of surgical site infections (SSI), therefore prophylactic antimicrobials have historically been used to minimize the incidence of SSI. Nevertheless, the use of prophylactic antibiotics in any form is progressively being questioned due to growing concerns about antimicrobial resistance. The aim of this retrospective study is to investigate the need of prophylactic antibiotics in canine patellar luxation surgery by examining infection rates and owner satisfaction. Through analysis of both quantitative medical records and qualitative surveys of owners, the study provides a comprehensive insight into the outcomes of patella luxation surgery.

For a more detailed analysis, the cases without any prophylactic antibiotics were divided into two groups based on the operations performed. In the main group, which included only patellar luxation surgery, the rate of surgical site infection (SSI) was 2.56%, significantly lower than the 5.4% reported for the same procedure with perioperative prophylactic antibiotics in the literature. Both SSIs occurred within three weeks of surgery and were effectively treated with cefazolin. In the smaller secondary group, including patella luxation surgery with a concurrent cranial crucial ligament rupture operation no SSIs were observed, although the limited sample size requires cautious interpretation. Comparison between the groups that received postoperative prophylactic antibiotics and those that did not receive any prophylactic antibiotics within the main group showed no significant difference in infection rates, suggesting that factors other than antibiotic administration influence the outcome.

In addition, patient satisfaction surveys emphasized the positive experience with the surgery and reported a low incidence of post-operative complications. Owners also reported that the dog's lameness had completely disappeared after an average of 5.3 weeks, providing a useful guide for clinicians to predict the patient's post-operative course after a patella luxation surgery.

The results in this cohort study of 101 dogs suggest that prophylactic antibiotics may not be necessary in patellar luxation surgery as they do not significantly affect infection rates. Besides the study encourages further research into the use of prophylactic antibiotics in orthopedic surgery to address the growing concern about antibiotic resistance.

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