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Review Article

Management of Long Bone Fractures in Cats Using Bone Plating System

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Abstract

A fracture refers to the occurrence of a break or interruption in the bone. The prevalence of long bone fractures in cats is on the rise due to the expanding population of domestic felines. The femur accounts for approximately 50.82% of long bone fractures, followed by the tibia-fibula at 29.05%, the radius-ulna at 10.61%, and the humerus at 9.5%. Motor vehicle accidents are the majority of fracture causes, accounting for 42.55% of cases. In contrast, dog biting, falls, and other accidents contribute to 12.76%, 4.25%, and 6.38% of fractures, correspondingly. Numerous treatments exist for managing fractures, including cerclage and Kirschner (K) wires, external skeletal fixation (ESF), bone plates, intramedullary pins, interlocking nail implantation, and the utilization of a combination bone plate-intramedullary pin construct, etc. The bone plating system is a modern and efficient method of internal fixing. There are many plating technologies that may be utilized for the purpose of correcting long bone fractures in felines such as dynamic compression plates (DCP), limited contact dynamic compression plate (LC-DCP), veterinary cuttable plates (VCP), locking plates, etc. In comparison to alternative fixation procedures, bone plates exhibit a superior recovery rate and a reduced incidence of post-operative complications. This study aims to exhibit different types of bone plates for the efficient execution of bone plating surgery and examine the effectiveness of bone plating systems in the treatment of long bone fractures in felines.

Introduction

Pet animal rearing has gained popularity throughout the world. People are keeping pet dogs and cats for leisure purposes or companionship. However, the ownership of cats as pets has increased in recent years, surpassing the number of owned dogs. Veterinary practitioners and experts are facing a rise in the frequency and diversity of fractures in cats, particularly in the humerus, radius-ulna, femur, and tibia-fibula, due to the large feline pet population. Cats are considered suitable candidates for orthopedic procedures due to their tiny size, low activity level, and their capacity to shift weight and safeguard a damaged leg. While feline orthopedics has similarities with treating canine bone fractures, it is important to note that cats have unique characteristics that require different approaches in the patient and fracture therapy (Scott et al., 2022; Hossain & Kayesh, 2014; Harari, 2002). A fracture occurs when there is a breakdown of bone continuity, either with or without fragment dislocation. There are usually variable degrees of soft tissue injury along with ripped arteries, bruising, lacerated periosteum, and contused nerves (Mahajan et al., 2015). The primary goal of fracture care is to achieve and sustain the alignment of fracture pieces as closely as possible to their natural anatomical location. This will facilitate the healing of the bone and soft tissues, ultimately restoring function to the damaged area (Presnell, 1978). Fracture care has developed over the last 50 years from traditional traction and counter-traction procedures to approaches utilizing internal fixation to facilitate an early return to limb function. Implant usage has evolved from meticulously reconstructing each fracture to recognizing the benefits of preserving the fracture site, leading to the development of procedures for 'biological fracture fixation' (Shales, 2008). The choice of a fixation method for these fractures is determined by the patient's size, the sturdiness of the fracture in the axial direction, any other musculoskeletal injuries present, and the state of the surrounding soft tissues (Slatter, 2003). Biological osteosynthesis techniques for treating comminuted long-bone fractures commonly involve cerclage and Kirschner (K) wires, external skeletal fixation (ESF), bone plates, intramedullary pins,

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interlocking nail implantation, and the use of a combined bone plate-intramedullary pin construct (Reems et al., 2003; Harari, 2002). Internal fracture fixation provides mechanical stability to a broken bone, enabling weight-bearing, early limb function, and rapid bone healing. Internal fixation often involves anatomical reduction, where each broken piece is promptly identified, realigned to its original location, and firmly secured (Aron et al., 1995). Bone plates are modern implants used for osteosynthesis (Voss et al., 2009). Since the 1960s, advancements have been made in the procedures and implants utilized for internal fixation using plates to enhance the healing process. Recently, plating approaches have emphasized the concepts of 'biological fixing'. These approaches aim to maintain the blood flow to enhance fracture healing, reduce the necessity for bone grafting, and lower the chances of infection and re-fracture. Bone plates are crucial for bone fracture healing since they provide the required mechanical stability for fractured fragments by influencing the biomechanical conditions at the fracture site. Effective treatment outcomes have been attained for bone fracture fixation using traditional bone plates composed of metallic stainless steel or titanium alloy (Li et al., 2020; Miclau & Martin, 1997).

While there has been much research on fracture care in cats, there is a scarcity of studies focusing on long bone fractures and related management strategies. There is a limited amount of research that specifically examines the benefits and drawbacks of bone plating systems compared to other fixing methods. This review aims to clarify several bone plating technologies applicable to long bone fractures in feline and assess their efficacy across different types of long bone fractures.

Anatomy of long bones

The term "long bones" refers to limb bones that are longer than their width. The structure is segmented along the longitudinal axis into three components: a central diaphysis, bordered by a pair of metaphyses, which are further accompanied by a pair of epiphyses at the termini of the bone (Coulier, 2021). Long bones are located in the limbs and serve as supportive pillars and levers, such as the humerus and femur bones (Vetscraft, 2023). Most sources state that around 50% of feline fractures affect the long bones (Harari, 2002).

Etiology of long bone fractures

Long bone fractures can be caused by direct or indirect trauma as well as pathological causes. Trauma frequently results in fractured long bones (Scott et al., 2022; Roush, 2005). According to a study by Cardoso et al., 2016, the majority of long bone fractures occur in the rear limbs, and the femur bone is the particular bone that is wounded the most frequently. 50.84% of the long bone fractures in small animals occur in the femur, followed by the tibia-fibula at 29.05%, and the radius-ulna at 10.61%, with the humerus at 9.50% (Cardoso et al., 2016). The most common cause of fractures is direct trauma to a bone, often resulting from a cat being struck by a vehicle or falling from a considerable height. Indirect stress to the bone can cause fractures by transferring force via bones or the adjacent muscles, tendons, and ligaments. Fractures of the femoral neck and avulsion fractures are typically the result of indirect trauma. Stress fractures in cats may be due to bone malformation like a mild form of osteogenesis imperfecta or a true fatigue fracture, rather than being completely caused by repeated low-grade trauma. Pathological fractures result from a disease weakening the bone, either through a localized primary bone condition (such as primary osteosarcoma), local invasion of bone by soft tissue sarcoma, or the skeletal system being affected by a systemic disease. Possible causes include neoplasia, infection, and nutritional or metabolic bone disorders (Cantatore & Clements, 2015; Brockley et al., 2012; Simon et al., 2000).

Classification of fractures

All fractures can be categorized as either closed (no skin break) or open (skin break). Open fractures typically result in more extensive injury to the surrounding soft tissues, such as the periosteum, leading to a greater risk of infection and a higher likelihood of non-union compared to closed fractures. Fractures of long bones like the femur, humerus, and tibia can be categorized based on the forces that cause them (Dhillon & Dhatt, 2012).

Basic fractures consist of transverse, oblique, spiral, avulsion, and incomplete fractures. Transverse fractures consist of a single fracture line that runs perpendicular to the bone's long axis. Oblique fractures are categorized as short or long based on the angle of the fracture line in relation to the long axis of the bone. Short oblique fractures have an angle between 30° and 45°, whereas long oblique fractures have an angle higher than 45°. Spiral fractures occur when twisting forces cause a fracture line that spirals along the length of the bone. An avulsion fracture occurs when a muscle, tendon, or ligament is forcefully pulled apart from the bone at its insertion point. An incomplete fracture is a fracture that affects only one cortex. A greenstick fracture in juvenile animals occurs when the intact cortex bends. A fissure fracture is a form of incomplete fracture characterized by a breaking of the bone that extends into the cortex but does not go through the entire bone. Comminute fractures, sometimes called multifragmental fractures, consist of several fracture lines that create one or more distinct pieces. If the fracture has less than two fragments, it is reducible. A fracture is classified as nonreducible if there are several little pieces that are smaller than one-third of the bone's diameter in length or breadth (DeCamp, 2015; Fossum, 2012).

Bone possesses remarkable regenerative capabilities. Ideally, bone heals without scarring and completely restores its form, structure, and function (Wildemann et al., 2021). Fracture healing depends on many factors. These can be divided into 2 types. The first is injury-related factors which include factors such as type of injury, movement near a break in the bone, separation of the bone ends, and disturbance of blood flow. The second type is patient-related factors that include age (young animals have faster bone healing rate), nutritional status of the animal, bone pathology, and severity of infection present at the site (Mirhadi et al., 2013).

Diagnosis of long bone fractures in cats

Radiography is the main imaging method utilized in veterinary orthopedics due to its cost-effectiveness, accessibility, and typically requiring sedation instead of full anesthesia (Deruddere et al., 2014). Veterinarians utilize X-rays for the majority of clinical fracture exams to ascertain the suitable therapy (Ergun & Guney, 2021). Veterinarians must possess a thorough grasp of the functionality and applications of diagnostic imaging technology, which is extensively employed in modern veterinary practice. X-rays remain the predominant imaging technique for producing diagnostic images on film.

Figure 1: X- ray of a cat having a complete femur fracture (red circle) after falling from 5th floor

Nevertheless, in many situations, using radiography is inadequate for evaluating and pinpointing lesions. Advanced imaging techniques such as magnetic resonance imaging (MRI) and computed tomography (CT) are being more commonly employed in veterinary medicine. Computed tomography outperforms radiography in detecting tiny bone fragments and is more dependable in seeing displacements within the fracture. It frequently enables accurate diagnosis and surgical treatment planning (Abako et al., 2021).

The advancement of imaging methods like micro-CT has allowed for a more thorough evaluation of bone disorders in tiny animals. Micro-CT utilizes a microfocal source to provide 2-D or 3-D spatial resolution that is not affected by the patient's body position. Micro-CT scanning has much lower patient exposure durations compared to traditional multislice CT scanning, with the fastest scanning time being 10 to 18 seconds. The benefits indicate that micro-CT might be utilized to get high-definition images to assist in diagnosing fractures (Sasai et al., 2015).

Basic principle of fixation techniques for long bone fractures

After the fracture has healed, the ultimate objective of fracture care is to make sure that the affected limb segment has been restored to its maximum potential level of function. Obtaining and then sustaining a reduction of the fracture with the use of an immobilization approach that allows the fracture to heal while simultaneously providing the patient with functional aftercare is the method that is utilized to accomplish this goal. The care of fractures may be broken down into two categories: nonoperative and operative approaches. The nonoperative technique involves performing a closed reduction, if necessary, and then immobilizing the affected area for a period of time via casting or splinting (if necessary). When a fracture is considerably displaced, closed reduction is required to treat the condition (McManus et al., 2008). Both surgical and nonsurgical approaches have evolved over time (Pape et al., 2019).

According to Shales, 2008, when selecting the most appropriate method to handle a specific fracture, it is important to consider basic guidelines, including fundamental concepts. The procedures involve:

- Aligning and stabilizing fractures to restore anatomical alignment.
- Ensuring fixation is stable to meet the needs of the fracture and injury.
- Employing delicate surgical methods to maintain blood supply to the bone and soft tissues.
- Prompt and safe mobilization of the patient and affected bone.

When dealing with articular fractures, it is important to consider preserving function and preventing callus development. The fundamentals of this fracture healing method are firm internal fixation, interfragmentary compression, anatomical restoration, and early recovery of joint motion (Shales, 2008).

Historically, the treatment of fractures has been considered the least urgent during the early therapy period. Recent data indicates that promptly stabilizing unstable fractures of the femur, pelvis, and even the spine can significantly decrease the morbidity and mortality in these patients. Prompt stabilization of fractures has several benefits for individuals with multiple-system injuries. Stabilizing fractures greatly decreases pain, leading to a decreased use of drugs. Enhanced fracture stability enables quicker rehabilitation of joints and muscles, leading to an early return to function and improved long-term outcomes for musculoskeletal injuries (Chapman, 1987).

Different types of bone plating system

Hansmann introduced the use of internal fixation plates and screws for long-bone fractures in 1886 (Woo et al., 1983). Danis realized in 1949 that the fracture pieces needed to be compressed. He used a plate he dubbed the "coapteur" to do this, which reduced interfragmentary motion and improved fixation stability. It resulted in a healing method he named "soudure autogène" (autogenous welding), which is currently referred to as primary bone healing (Danis, 1949). All other plate designs were influenced by his ground-breaking idea (Igna & Schuszler, 2021). The Lane plate and the Sherman plate were designed and commonly used around the beginning of the century. The plates were not sufficiently stiff according to current standards and did not effectively stabilize shattered bone ends, particularly in the treatment of femoral fractures. Furthermore, electrolysis posed a big issue. Stainless steel implants were not available for internal fixation plates and screws until later. Over the next 30 years, advancements in plate design and strength led to plate breaking being a rare cause of failure (Woo et al., 1983).

The Dynamic Compression Plate

Sometimes known as DCP, it was created and debuted in 1969 for treating fractures. The Dynamic Compression Plate (DCP) is a plate that provides axial compression by utilizing a screw with a spherically undercut head inserted eccentrically in an inclined hole in the plate. The screw head makes direct contact with the walls of the plate hole, reducing sideways movement and stress on the implant. The implant has been effectively utilized as a tension band, neutralization, compression, and buttress plate because of the similar screw head-to-plate hole fit (Miclau & Martin, 1997). Dynamic compression plates (DCPs) generate compression at a fracture or osteotomy site by tightening a screw inserted off-center within an oval screw hole. 'Dynamic' compression should enhance primary bone repair by eliminating interfragmentary gaps. Compression also enhances friction between the bone ends, which enhances the stability of the structure. Dynamic compression plates (DCPs) can be used with screws positioned centrally in the screw hole to provide no interfragmentary compression. This is suitable for comminuted fractures when achieving compression is not necessary (Scott et al., 2022).

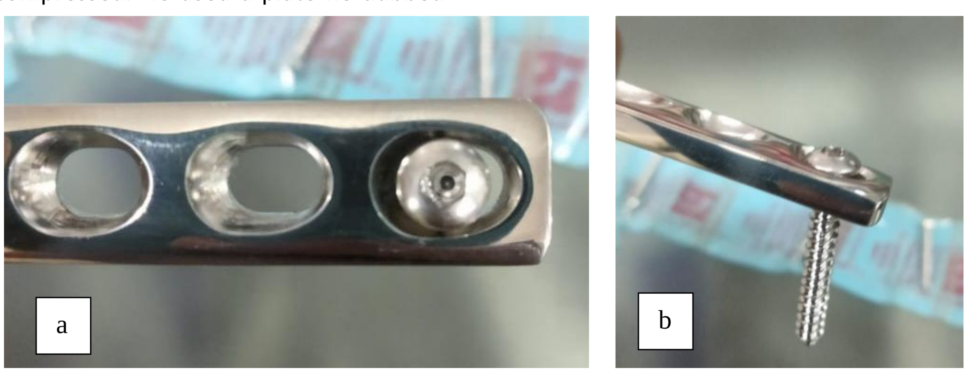

Figure 2: A 3.5 mm Dynamic Compression Plate (DCP) with screw (a) top view, (b) side view

The limited contact dynamic compression plate (LC-DCP)

The LC-DCP was the second-generation plate created by the AO group (Perren et al., 1990). Both plates are used in the same way. The DCP and LC-DCP plates differ in form, resulting in reduced bone contact and encouraging enhanced healing due to the design of the LC-DCP plate (Ayyappan, 2013).

The LC-DCP, like other traditional internal fixation implants, is manufactured from a prismatic metal piece using cutting tools. When viewed from above, the LC-DCP's look is defined by the evenly spaced plate holes. The plate holes are symmetrical and have two identical self-compressing inclined surfaces at either end. The plate's side sides are slightly slanted to create a trapezoidal cross-section with undercuts that produce arcs. The cross-section at these places has two highly sloped sides. Traditional plates with a prismatic outer form, without reducing the cross-section between plate holes, have reduced stiffness inside the plate hole range compared to the complete section between plate holes. This results in a significant decrease in stiffness at the hole location on the plate. When a plate is bent or twisted, the deformation mostly occurs at the hole in the plate (Perren et al., 1990).

Tubular plates

One-third tubular plates are beneficial for repairing lengthy bone fractures in cats. Tubular plates are thin and have a low profile, allowing them to tightly conform to the bone surface, which makes it easier to seal the soft tissues over the plate. The torsional and bending strengths remain reasonably high because to their partly tubular structure (Scott et al., 2022).

The Veterinary Cuttable Plates (VCP)

It is challenging to cut a plate that is rigid enough to endure the stresses in intricate fractures of the long bones of small dogs and cats using wire cutters or similar tools. Plates were designed to be cuttable and adjustable in length for selecting the optimum size for the fracture. Their rigidity may be enhanced by sandwiching two plates together (Brüse et al., 1989). Veterinary Cuttable Plates have been created and are becoming popular among practicing veterinarians. The Veterinary Cuttable Plates (VCPs) may be trimmed to a certain length to match the bone size and can also be layered on top of each other if necessary. VCPs, being narrow, thin, and elastic, are ideal for repairing fractures (Ramesh et al., 2018).

Locking plates

A locking plate system involves screws that lock into the plate hole instead of being squeezed into it by rotating torque from the screw thread. The locking mechanism is usually created by using a threaded screw head and a matching threaded profile in the plate hole, both with a little taper, ensuring they interlock when the screw head reaches the base of the plate hole (Arthurs, 2015). Variation is present in the locking process, plate characteristics, plate as well as screw material, and plate pattern (Scott et al., 2022).

The unilock mandible locking plate system

The unilock mandible locking plate system was specifically created for treating mandibular fractures in humans. It has been demonstrated to be an appropriate implant for this purpose via biomechanical and clinical research (Schupp et al., 2007; Gellrich et al., 2004). Voss et al. began using the technique for stabilizing long-bone fractures in cats and small dogs in 2009, due to the limited availability of internal fixators in suitable sizes for small animals.

Surgical procedure of bone plating in cats

The plate size is mostly determined by the patient's weight and the relative size of the bone. It is important to take into account the body condition score (BCS) of the animal (Sylvestre, 2019). The screw size is chosen according to the bone's dimensions. Screws should be chosen with a shank diameter that is around 20%–30% of the bone diameter to maintain the integrity of the bones since studies have demonstrated a significant decrease in bone strength when circular cortical defects exceed 30% of the bone diameter. The plate size corresponds to the screw size, so a 2.4 mm plate is compatible with 2.4 mm screws. The 20%–30% guideline is also relevant for other implants that interact with bone, including the transfixation pins used in external skeletal fixation (Scott et al., 2022).

While plate systems may vary, the fundamental principles in plate and screw application are consistent. Screws are inserted after predrilling using a drill bit that has a diameter similar to the core diameter of the screw (Theyse, 2014). Screws can be utilized independently for femoral neck fractures and intercondylar fractures of the distal humerus and femur. One screw is frequently utilized alongside a Kirschner wire in these scenarios to inhibit rotation. Using screws alone for diaphyseal fractures is not recommended due to the risk of loosening and collapse at the fracture site with weight bearing. Screws are utilized in conjunction with plates for diaphyseal fractures and all comminuted fractures of long bones, including fractures that extend into joints (Nunamaker, 1985).

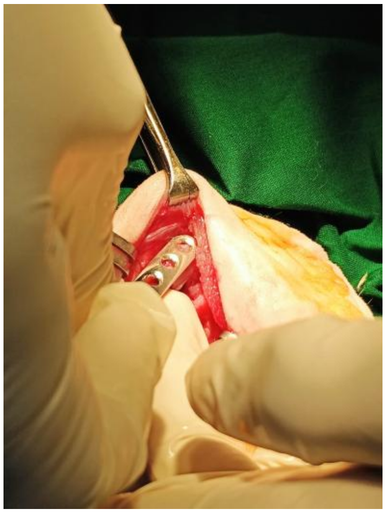

Figure 3: Placing a bone plate in the fractured femur during surgery.

Placing screws near the fracture ends should be avoided to prevent interference with surrounding joints. A recommended minimum distance of 1 cm from the fracture line is suggested, based on the patient's size. When treating fractures in long bones, it is important to use the whole length of the bone to minimize stress on implants and the area of the fracture. Minimally invasive approaches can be utilized during osteosynthesis to reduce surgical stress while maintaining functional fracture alignment and stability as the major objectives. Fracture healing progress is evaluated using radiographic imaging 4 to 6 weeks post-surgery (Theyse, 2014).

Historically, the removal of all bone plates has been advised by the Association for the Study of Internal Fixation. However, there has been disagreement about the specifics of whether or when to remove a particular bone plate. The patient's age, the kind of bone concerned, and the rate at which the fracture heals all influence when it is best to remove the plate (Conzemius & Swainson, 1999). Fracture recovery often requires many months, and the removal of the plate is normally scheduled no earlier than 6 months post-surgery. The decision to remove plates and screws is based on the plate's position and its impact on soft tissue function. Lameness can arise in cold weather when plates are positioned with insufficient skin covering. It is advisable to have an annual radiographic examination while plates and screws are retained in place. Any lameness associated with implants should be carefully evaluated (Theyse, 2014). It is very important to follow a suitable protocol for performing a bone plate fixation surgery. The occurrence of fracture fixation failure after plating frequently gives rise to complex surgical revision scenarios. A thorough examination of all patient and fracture factors is beneficial for identifying the reasons behind the failure of the fixation and optimizing the effectiveness of following treatments. It is necessary to take into account both biological and mechanical aspects. Biological factors to be taken into account encompass traumatic soft-tissue damage and the presence of an atrophic fracture site. Malreduction, insufficient plate length or strength, and excess or inadequate build stiffness are frequently cited as mechanical factors contributing to failure (Gardner et al., 2009).

Sardinas & Montavon, 1997, demonstrated the basic steps for performing bone plating in small animals (Sardinas & Montavon, 1997). The steps include-

- The injured limb should undergo routine orthopedic surgical preparation, along with a typical operational technique.
- The injured limb can be up or down depending on the condition of the fracture when the patient is in lateral recumbency.
- The fracture's medial or lateral face would be towards the ceiling, giving the surgeon excellent exposure to the fracture area.
- Depending on where the fracture occurs, the length of the skin incision and access to the bone would change. The incision would be made across the medial or lateral border of the bone.
- An incision must be made in the subcutaneous and deep antebrachial fascia on a line parallel to the bone.
- This placement together with stretching the limb over the edge of the operating table is necessary to help in the reduction of the fracture.
- Placing the plate along the broken area's surface is recommended. Drilling should be done with the assistance of the equipment.

- To conclude the surgical operation, the subcutaneous and dermal layers should be closed.
- A gentle, padded bandage is advised to lessen swelling following surgery.

Healing of fractures and complication rate among different techniques

Postoperative problems may occur following a bone plating operation regardless of its effectiveness. Prominent side effects comprise soreness, exposure, soft tissue eroding, and infection. There is a broad spectrum of discomfort associated with titanium plating, ranging from pain and cold sensitivity to simple palpability across sensitive facial regions. Secondary operational operations are frequently required to remove previously placed devices due to these problems (Nagase et al., 2005). Other postoperative complications include dehiscence of the wound, osteomyelitis, malunion, nonunion, paresthesia of the nerves, hardware failure (damaged plate, loosened screw), etc. (Al-Hammami et al., 2018).

A study was conducted by Könning et al. in 2013 on 106 cats with femoral diaphyseal fractures, where 30 cats were treated with external fixation techniques, 56 cats had plate-rod construct and 20 cats received bone plates. The result showed that the group with external fixations had more complications than the group with bone plate fixations. The healing time was also much faster in the bone plate receiving group than in the other.

A similar result was found in another study by Longley et al., in 2018 where 12 cats were taken into account for the management of humeral fractures. The external fixation group showed more complications (86%) than the group with plates and screws (26.7%).

Another study by Wallace et al., 2009 showed that, the bone plate system has a lower complication rate than external fixation techniques. 28.6% of the patients needed a revision surgery in case of external skeletal fixators (ESF) whereas the rate of revision surgery was required in 10% of the cases with bone plating system.

Gall et al., 2022 reported that bone plate fixation gains union in less time than pin-plate and external fixation methods. They conducted a research on 57 cats having humeral diaphyseal fractures and used 3 techniques for fixation of the fractures. Among these techniques, bone plates gained complete union in less than 100 days where external skeletal fixator and pin-plate construct took >100 days to achieve union.

The optimal approach for addressing diaphyseal fractures involves the utilization of plate fixation, followed by internal fixation with pins (Paskalev, 1998). In a comparative study between intramedullary pinning and bone plating system, Presnell, 1978 demonstrated that the screw approach is most effective for treating fractures of the femoral neck, intercondylar fractures of the distal femur or humerus, and slab fractures of the tibia. Compression and stabilization of intraarticular fractures can be achieved using screws and plates. Pins are also effective for these fractures, although the narrow medullary canal of the radius allows only a tiny pin to be inserted proximally, necessitating additional external assistance. Plates may be easily attached to the radius and offer exceptional stability. Comminuted fractures can be treated with pinning and complete cerclage wiring if there are just one or two big pieces in addition to the two major fragments. If there are several little bone fragments or a defect that has to be kept in distraction, using a plate and screws will offer the most stability and should be utilized. Nonunions are most effectively treated with plate fixation due to the delayed healing process, necessitating prolonged stability. Compression at the fracture site seems to promote the healing process in cases of nonunion or delayed union.

Current researchers indicate a shift from tension band wiring to more rigid surgical structures like plate and screw fixation. The change in treatment choice is mainly because there is little evidence that tension bands effectively change tension forces to articular compression (Lervick, 2016). While K-wire fixation is a cost-effective and often utilized technique for stabilizing metacarpal shaft fractures, research indicates that the fixation strength of K-wires is significantly inferior to that of bone plates (Chiu et al., 2021).

Emmerson & Muir, 1999, demonstrated the major reasons for post-operative complications and reasons for bone plate removal. The main reasons for bone plate include implant breakage or loosening which accounts for 48% of the cases.

The benefits of the dynamic compression plate (DCP) are a reduced occurrence of malunion, secure internal fixation, and the absence of external immobilization, enabling rapid mobility of adjacent joints. Precise surgical techniques and a high-quality education program also enhanced the benefits and effectiveness of this plating method (Uhthoff et al., 2006). According to Kotwal, 2008, among several plates, the dynamic compression plate (DCP) is considered the most optimal choice for the internal fixation of fractures in diaphyseal long bones. However, the DCP has drawbacks such as delayed union and the presence of a noticeable fracture gap that might function as a stress raiser after removing the plate (Uhthoff et al., 2006). Locking plates offer improved bone grip, particularly in osteoporotic bone, but implant pull-out can still occur. Delayed fractures at the plate ends can be prevented by making appropriate biomechanical decisions during fixing. Epiphyseal fractures provide dangers of cut-out and impaction of locking screws in the cancellous bone due to the fracture pathology. Long-term use of locking plates may present challenges during removal (Bel, 2019).

Conclusion

The optimal approach for treating long bone fractures relies on the surgeon's expertise. The process of bone plating is both costly and time-consuming. Nevertheless, the effectiveness of this method is exceptional when executed correctly. Different types of bone plates can be used in different types of long bone fractures. A surgeon should have knowledge about different types of bone plating systems to get maximum results in fracture management. All types of internal fixation methods have their own contraindications. Post-operative complications can occur in any kind of fracture management technique. However, the occurrence of post-operative complications is less in bone plating system which indicates the possible use of bone plates in the successful repair of long bone fractures in cats.

References

Abako, J., Holak, P., Głodek, J., & Zhalniarovich, Y. (2021). Usefulness of Imaging Techniques in the Diagnosis of Selected Injuries and Lesions of the Canine Tarsus. A Review. *Animals*, *11*(6), 18-34. https://doi.org/10.3390/ani11061834

Al-Hammami, A. R., Al-Anee, A. M., Lateef, T. A., & Al-khayat, A. (2018). Complications of Bone Plating Following Different Facial Bones Fractures. *European Scientific Journal, ESJ*, *14*(6), 351. https://doi.org/10.19044/esj.2018.v14n6p351

Aron, D. N., Johnson, A. L., & Palmer, R. H. (1995). Biologic strategies and a balanced concept for repair of highly comminuted long bone fractures. *The Compendium on Continuing Education for the Practicing Veterinarian (USA), 17(1),* 37-49.

Arthurs, G. (2015). Advances in internal fixation locking plates. *In Practice*, *37*(1), 13–20. https://doi.org/10.1136/inp.g7695

Ayyappan, S. (2013). AO techniques of Dynamic Compression Plate (DCP) and Limited Contact Dynamic Compression Plate (LC–DCP) Application for Fracture Management in Dogs. *Advances in Animal and Veterinary Sciences, 1(2S),* 33-36.

Bel, J.-C. (2019). Pitfalls and limits of locking plates. *Orthopaedics & Traumatology: Surgery & Research*, *105*(1), 103–109. https://doi.org/10.1016/j.otsr.2018.04.031

Brockley, L. K., Heading, K. L., Jardine, J. E., Moore, P. F., & Bennett, P. F. (2012). Polyostotic lymphoma with multiple pathological fractures in a six-month-old cat. *Journal of Feline Medicine and Surgery*, *14*(4), 285–291.

Brüse, S., Dee, J., & Prieur, W. D. (1989). Internal Fixation with a Veterinary Cuttable Plate in Small Animals. *Veterinary and Comparative Orthopaedics and Traumatology*, *02*(01), 40–46. https://doi.org/10.1055/s-0038-1633188

Cantatore, M., & Clements, D. N. (2015). Bilateral calcaneal stress fractures in two cats. *Journal of Small Animal Practice*, *56*(6), 417–421. https://doi.org/10.1111/jsap.12358

Cardoso, C. B., Rahal, S. C., Agostinho, F. S., Mamprim, M. J., Santos, R. R., Filho, E. S., Mortari, A. C., & Monteiro, F. O. B. (2016). Long bone fractures in cats: a retrospective study. *Veterinária e Zootecnia*, *23*(3), 504-509.

Chapman, M. W. (1987). Orthopedics: Immediate Stabilization of Fractures in Patients With Multiple-Systems Injuries. *Western Journal of Medicine*, *146*(4), 467.

Chiu, Y. C., Hsu, C. E., Ho, T. Y., Ting, Y. N., Tsai, M. T., & Hsu, J. T. (2021). Bone plate fixation ability on the dorsal and lateral sides of a metacarpal shaft transverse fracture. *Journal of orthopaedic surgery and research*, *16*(1), 441.

Conzemius, M., & Swainson, S. (1999). Fracture Fixation with Screws and Bone Plates. *Veterinary Clinics of North America: Small Animal Practice*, *29*(5), 1117–1133. https://doi.org/10.1016/S0195-5616(99)50105-8

Coulier, A. (2021). *Multiscale modeling in systems biology: methods and perspectives* (Doctoral dissertation, Acta Universitatis Upsaliensis).

Danis, R. (1949). *Théorie et pratique de l'ostéosynthèse*. Masson & Cie, Éditeurs, Libraires de l'Académie de Médecine.

DeCamp, C. E. (2015). *Brinker, Piermattei and Flo's handbook of small animal orthopedics and fracture repair*. Elsevier Health Sciences.

Deruddere, K. J., Milne, M. E., Wilson, K. M., & Snelling, S. R. (2014). Magnetic Resonance Imaging, Computed Tomography, and Gross Anatomy of the Canine Tarsus. *Veterinary Surgery*, *43*(8), 912–919. https://doi.org/10.1111/j.1532-950X.2014.12194.x

Dhillon, M. S., & Dhatt, S. S. (2012). *First aid and emergency management in orthopedic injuries*. JP Medical Ltd.

Doijode, V., Desai, D., & Bhari, S. (2018). Comparative Evaluation of Veterinary Cuttable Plate and Polypropelene Mesh Impregnated PMMA Plate for Fracture Repair of Tibia Bone in Goats. *International Journal of Livestock Research*, *8*(5), 160. https://doi.org/10.5455/ijlr.20170731051307

Emmerson, T. D., & Muir, P. (1999). Bone Plate Removal in Dogs and Cats. *Veterinary and Comparative Orthopaedics and Traumatology*, *12*(02), 74–77. https://doi.org/10.1055/s-0038-1632466

Ergun, G. B., & Guney, S. (2021). Classification of Canine Maturity and Bone Fracture Time Based on X-Ray Images of Long Bones. *IEEE Access*, *9*, 109004–109011. https://doi.org/10.1109/ACCESS.2021.3101040

Fang, Y. (2018). *A retrospective study of postoperative complications after fracture repair in dogs and cats, with focus on fractures in the radius and ulna*.

Fossum, T. W. (2012). *Small Animal Surgery Textbook-E-Book*. Elsevier Health Sciences.

Gall, N., Parsons, K., Radke, H., Comerford, E., Mielke, B., Grierson, J., Ryan, J., Addison, E., Logethelou, V., Blaszyk, A., & Langley-Hobbs, S. J. (2022). Analysis of feline humeral fracture morphology and a comparison of fracture repair stabilisation methods: 101 cases (2009–2020). *Journal of Feline Medicine and Surgery*, *24*(6), 19–27. https://doi.org/10.1177/1098612X221080600

Gardner, M. J., Evans, J. M., & Dunbar, R. P. (2009). Failure of Fracture Plate Fixation. *JAAOS - Journal of the American Academy of Orthopaedic Surgeons*, *17*(10), 647.

Gellrich, N.-C., Suarez-Cunqueiro, M. M., Otero-Cepeda, X. L., Schön, R., Schmelzeisen, R., & Gutwald, R. (2004). Comparative study of locking plates in mandibular reconstruction after ablative tumor surgery: THORP versus UniLOCK system. *Journal of Oral and Maxillofacial Surgery*, *62*(2), 186–193.

Harari, J. (2002). Treatments for feline long bone fractures. *Veterinary Clinics of North America: Small Animal Practice*, *32*(4), 927–947. https://doi.org/10.1016/S0195-5616(02)00025-6

Hossain, S. S. M. R., & Kayesh, M. E. H. (2014). Common diseases of pet animals in Dhaka city and their zoonotic importance. *International Journal of Natural and Social Sciences*, *1*, 81-84..

Igna, C., & Schuszler, L. (2010). Current concepts of internal plate fixation of fractures. *Bulletin UASVM, Veterinary Medicine*, *67*(2), 118-124.

Könning, T., Maarschalkerweerd, R. J., Endenburg, N., & Theyse, L. F. H. (2013). A comparison between fixation methods of femoral diaphyseal fractures in cats – a retrospective study. *Journal of Small Animal Practice*, *54*(5), 248–252. https://doi.org/10.1111/jsap.12061

Kotwal, P. P. (2008). Fractures of the Radius and Ulna. *Textbook of Orthopaedics and Trauma*, *2*, 2.

Legnani, C., Dondi, A., & Pietrogrande, L. (2013). Conservative treatment of a femoral neck fracture following nail removal. *Journal of Mid-Life Health*, *4*(3), 191. https://doi.org/10.4103/0976-7800.118995

Lervick, G. N. (2016). Olecranon fractures. *Shoulder and Elbow Trauma and its Complications*, 167-191.

Li, J., Qin, L., Yang, K., Ma, Z., Wang, Y., Cheng, L., & Zhao, D. (2020). Materials evolution of bone plates for internal fixation of bone fractures: A review. *Journal of Materials Science & Technology*, *36*, 190–208. https://doi.org/10.1016/j.jmst.2019.07.024

Longley, M., Chase, D., Calvo, I., Hall, J., Langley-Hobbs, S. J., & Farrell, M. (2018). A comparison of fixation methods for supracondylar and distal humeral shaft fractures of the dog and cat. *The Canadian Veterinary Journal*, *59*(12), 1299–1304.

Mahajan, T., Ganguly, S., & Para, P. A. (2015). Fracture management in animals: a review. *J Chem Biol Phys Scs*, *4*, 4053-4057.

McManus, J. G., Morton, M. J., Crystal, C. S., McArthur, T. J., Helphenstine, J. S., Masneri, D. A., Young, S. E., & Miller, M. A. (2008). Use of ultrasound to assess acute fracture reduction in emergency care settings. *American Journal of Disaster Medicine*, *3*(4), 241–247.

Miclau, T., & Martin, R. E. (1997). The evolution of modern plate osteosynthesis. *Injury*, *28*, 3-6.

Mirhadi, S., Ashwood, N., & Karagkevrekis, B. (2013). Factors influencing fracture healing. *Trauma*, *15*(2), 140–155. https://doi.org/10.1177/1460408613486571

Nagase, D. Y., Courtemanche, D. J., & Peters, D. A. (2005). Plate removal in traumatic facial fractures: 13-year practice review. *Annals of Plastic Surgery*, *55*(6), 608–611.

Nunamaker, D. M. (1985). Methods of internal fixation. In *:* (pp. 261-86.). JB Lippincott.

Pape, H.-C., Halvachizadeh, S., Leenen, L., Velmahos, G. D., Buckley, R., & Giannoudis, P. V. (2019). Timing of major fracture care in polytrauma patients – An update on principles, parameters and strategies for 2020. *Injury*, *50*(10), 1656–1670. https://doi.org/10.1016/j.injury.2019.09.021

Paskalev, M. (1998). *Comparative evaluation of various techniques for surgical repair of bone fractures in dogs and cats*. *4*(1). https://agris.fao.org/search/en/records/64722e2308fd68d546ffe592

Perren, S. M., Mane, K., Pohler, O., Predieri, M., Steinemann, S., & Gautier, E. (1990). The limited contact dynamic compression plate (LC-DCP). *Archives of Orthopaedic and Trauma Surgery*, *109*(6), 304–310. https://doi.org/10.1007/BF00636166

Presnell, K. R. (1978). Pins Versus Plates: The Orthopedic Dilemma. *Veterinary Clinics of North America*, *8*(2), 213–217. https://doi.org/10.1016/S0091-0279(78)50029-4

Ramesh, N., Chandra Sekhar, E. L., Raghavender, K. B. P., & Purushotham, G. (2018). A clinical study on the use of veterinary Cuttable plates for femoral diaphyseal fractures in small dog breeds and puppies. *J. Entom. and Zool. Stud*, *6*(1), 473-476.

Reems, M. R., Beale, B. S., & Hulse, D. A. (2003). Use of a plate-rod construct and principles of biological osteosynthesis for repair of diaphyseal fractures in dogs and cats: 47 cases (1994–2001). *Journal of the American Veterinary Medical Association*, *223*(3), 330–335. https://doi.org/10.2460/javma.2003.223.330

Roush, J. K. (2005). Management of Fractures in Small Animals. *Veterinary Clinics of North America: Small Animal Practice*, *35*(5), 1137–1154. https://doi.org/10.1016/j.cvsm.2005.06.001

Sardinas, J. C., & Montavon, P. M. (1997). Use of a Medial Bone Plate for Repair of Radius and Ulna Fractures in Dogs and Cats: A Report of 22 Cases. *Veterinary Surgery*, *26*(2), 108–113. https://doi.org/10.1111/j.1532-950X.1997.tb01472.x

Sasai, H., Fujita, D., Tagami, Y., Seto, E., Denda, Y., Hamakita, H., Ichihashi, T., Okamura, K., Furuya, M., Tani, H., Sasai, K., & Yamate, J. (2015). Characteristics of bone fractures and usefulness of micro–computed tomography for fracture detection in rabbits: 210 cases (2007–2013). *Journal of the American Veterinary Medical Association*, *246*(12), 1339–1344. https://doi.org/10.2460/javma.246.12.1339

Schupp, W., Arzdorf, M., Linke, B., & Gutwald, R. (2007). Biomechanical testing of different osteosynthesis systems for segmental resection of the mandible. *Journal of Oral and Maxillofacial Surgery*, *65*(5), 924–930.

Scott, H., Marti, J., & Witte, P. (2022). *Feline Orthopaedics* (2nd ed.). CRC Press. https://doi.org/10.1201/9780429091537

Shales, C. (2008). Fracture management in small animal practice: 1. Triage and stabilisation. *In Practice*, *30*(6), 314–320. https://doi.org/10.1136/inpract.30.6.314

Simon, D., Gruber, A. D., Hewicker‐Trautwein, M., & Nolte, I. (2000). Pathological femoral fracture due to rhabdomyosarcoma in a cat. *Journal of Small Animal Practice*, *41*(12), 566–570.

Slatter, D. H. (2003). *Textbook of small animal surgery* (Vol. 1). Elsevier health sciences.

Sylvestre, A. M. (2019). Plating. In A. M. Sylvestre (Ed.), *Fracture Management for the Small Animal Practitioner* (1st ed., pp. 223–233). Wiley. https://doi.org/10.1002/9781119215950.ch21

Theyse, L. F. H. (2014). Fracture fixation: Plates. *Orthopaedics*. 39th World Small Animal Veterinary Assosciation Congress.

Uhthoff, H. K., Poitras, P., & Backman, D. S. (2006). Internal plate fixation of fractures: Short history and recent developments. *Journal of Orthopaedic Science*, *11*(2), 118–126. https://doi.org/10.1007/s00776-005-0984-7

Vetscraft. (2023, April 3). Classification of bones. *Classification of Bones*. https://www.vetscraft.com/classification-of-bones/

Voss, K., Kull, M. A., Haessig, M., & Montavon, P. M. (2009). Repair of long-bone fractures in cats and small dogs with the Unilock mandible locking plate system. *Veterinary and Comparative Orthopaedics and Traumatology*, *22*(05), 398–405. https://doi.org/10.3415/VCOT-08-09-0084

Wallace, A. M., De La Puerta, B., Trayhorn, D., Moores, A. P., & Langley-Hobbs, S. J. (2009). Feline combined diaphyseal radial and ulnar fractures. A retrospective study of 28 cases. *Veterinary and Comparative Orthopaedics and Traumatology: V.C.O.T*, *22*(1), 38–46.

Wildemann, B., Ignatius, A., Leung, F., Taitsman, L. A., Smith, R. M., Pesántez, R., Stoddart, M. J., Richards, R. G., & Jupiter, J. B. (2021). Non-union bone fractures. *Nature Reviews Disease Primers*, *7*(1), 57.

Woo, S. L., Lothringer, K. S., Akeson, W. H., Coutts, R. D., Woo, Y. K., Simon, B. R., & Gomez, M. A. (1983). Less rigid internal fixation plates: Historical perspectives and new concepts. *Journal of Orthopaedic Research*, *1*(4), 431–449. https://doi.org/10.1002/jor.1100010412.