The Pharma Innovation Journal 2023; 12(5): 204-208

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; 12(5): 204-208

www.thepharmajournal.com
Received: 08-02-2023
Accepted: 12-03-2023

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Closed biological osteosynthesis with external fixer type I in comminuted old fracture of humerus in dog: Case report

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Abstract
Fractures are routinely observed in the surgical practice of small animals, caused mainly by automobile accidents, firearms, and falls. Biological osteosynthesis is commonly used in irreducible comminuted fractures located in diaphysis of long bones. The objective of this study was to report the success of a closed biological osteosynthesis by means of an external fixator type I, performed in an irreducible comminuted fracture in the middle third of a humerus in a large breed dog, caused by an automobile accident. The patient was submitted to biological osteosynthesis with the use of external skeletal fixator applied in a closed manner, without any manipulation of the fracture focus. With the total restoration of the bone, visualized by the imaging examinations and the clinically observed function of the limb, it was possible to conclude that the application of Type 1 external fixator in a closed manner allowed the fracture alignment without manipulation of the fragments even though an old fracture.

Keywords: Surgery, orthopedics, small animal medicine, radiology

Introduction
Orthopedic injuries, especially fractures, are commonly identified in the surgical practice of small animals. There are several etiologies for a fracture, such as accidents with vehicles, falls, and firearms, as well as other non-specific high impact traumas in general (Florês, 2013) [1]. The trauma commonly can cause fragmentation of the focus of the fracture, characterizing the fractures as comminuted. These may be reducible when there are large fragments capable of anatomical reconstruction; or nonreducible, when there are small fragments that cannot be regrouped and individually stabilized (Johnson and Hulse, 2015) [2].
According to Schutz and Sudkamp, (2003) [3], it was known that in cases of internal fixation, the ideal was to prevent as much as possible the mobility of the fragments. However, in biological osteosynthesis, there is no need for maximum stabilization, and yet, good results in both humans and animals are reported (Hudson *et al.*, 2009; Guiot and Déjardin, 2011) [4, 5]. This is possible because biological osteosynthesis is used, especially in irreducible diaphyseal comminuted fractures, which have a low strain, allowing a greater motion of the fracture focus. In addition, in biological osteosynthesis, there is greater conservation of local vascularization, which leads to the early formation of bone callus (Serafini *et al.*, 2014) [6].
In long bone osteosynthesis, implant placement can be done in a closed, minimally invasive or open manner (Reems, 2003) [7]. The open reduction is usually the most used option, where the fixation and perfect alignment of the fragments is done. In the open reduction, the visualization and reduction of the fragments are more accessible, however, a greater blood compromise can occur, which impairs bone healing (Guiot and Déjardin, 2011) [5]. In closed reduction and minimally invasive techniques, large bone fragments near adjacent joints are aligned without exposing the fracture focus, preserving the rich initial fracture hematoma that has rich osteogenic growth factors (Gemmill, 2007) [8].
The maintenance of the clot that occurs after the initial hematoma of a fracture activates the complement cascade, leading to the activation of inflammatory cells and interleukins that will result in the production of prostaglandins, which are produced by osteoblasts under COX-2 stimulus, controlling the remodeling and consequently accelerating the union of the bone

segments. In addition, the platelets present in the clot are rich in growth factors, which stimulate mitosis, cell differentiation and angiogenesis (Denny and Butterworth, 2006) [9]. The adequate vascularization of the bone fragments ensures the nutritional contribution to the periosteum favoring the early formation of the bone callus and consequent stabilization of the fracture (Piermattei *et al.*, 2009) [10].

The use of closed external fixer is made on the percutaneous implantation of pins overlying the skin, soft tissues and cortical bone. The external fixation is done by means of metal bars or self-curing acrylic rods (Nóbrega, 2008.) [11]. Tong and Bavonratanavech (2009) [12], add that the small skin incision and the small dissection of the soft tissues adjacent to the fracture lead to lessening the chances of infection and postoperative pain, in addition to providing accelerated healing.

In the case of chronic fractures, there is evident muscular contracture and greater difficulty in recovering the length and alignment of the affected bone (Beale and Mccally, 2012) [13]. In addition, there is a possibility of nonunion of the bone fragments (Piermattei *et al.,* 2006; Fossum, 2007) [14, 15]. Nonunion can lead a pseudoarthrosis resulting from chronic movements at the fracture site because the empty site is filled with fibrocartilage, giving rise to a fibrous capsule filled with serous fluid (Henry, 2007) [16].

In view of this information, the objective was to report the success of a closed biological osteosynthesis with an external fixator type I, performed in a nonreducible comminuted chronic fracture in the middle third of a humerus in a large breed dog, caused by an automobile accident.

Case report

A male, of the canine species, without a defined breed of 1 year, 38kg, with claudication without the support of the left thoracic limb was attended. The tutor reported that the animal was rescued from the street after a car accident three days ago.

At the general physical examination, pale mucous membrane was observed; lymphadenopathy of submandibular and popliteal lymph nodes; and elevated body temperature (39.8 °C). The other general parameters were within the normal range. In the orthopedic examination, pain, swelling, crackling and instability were observed in the left humerus diaphyseal region.

The hematologic evaluation revealed regenerative anemia, thrombocytopenia, and lymphopenia. PCR for ehrlichiosis was requested which was positive. Serum alanine aminotransferase and creatinine enzymes showed values within the normal range. With the radiographic examination, in the mediolateral and craniocaudal positions of the left humerus, it was possible to evidence an irreducible comminuted fracture of humeral diaphysis (Figure 1).

Fig 1: Radiographic images of the left humerus of the dog, mixed breed, 1 year, showing comminuted diaphyseal fracture with a deviation of the bone axis in the middle third with the presence of countless bone fragments in the fracture focus. In A, craniocaudal projection; in B, mediolateral projection.

After the diagnosis of the fracture, surgery was indicated for its correction. However, due to the associated ehrlichiosis, surgery was postponed until the reestablishment of better systemic clinical conditions. The patient was treated for 28 days with Doxycycline at a dose of 5 mg / kg, every 12 hours. After this period, the patient was in good clinical and hematological conditions; thus, he was subjected to humeral osteosynthesis.

The patient received pre-anesthesia with acepromazine (0.05 mg / kg) associated with morphine (0.5 mg / kg) intramuscularly. Anesthetic induction was performed with intravenous propofol (10 mg / kg), ketamine (1 mg / kg) and midazolam (0.2 mg / kg) and anesthesia maintenance was performed with isoflurane. The left thoracic limb trichotomy was performed, the patient was placed in dorsal decubitus with the left thoracic limb suspended. Previous and definitive antisepsis was performed with a solution of 2% chlorhexidine followed by 70% alcohol.

Small cutaneous incisions and discrete lateral divulsion of the musculature were made at the proximal and distal ends of the humerus to expose the bone. Two 3.5 mm shanz pins were placed on each end of the bone in a closed manner, without exposing the focus of the fracture. The ends were aligned and the pins were stabilized with polymethylmethacrylate sidebar, making a type I fixative (Figure 2). The skin was sutured in "U" pattern with 3-0 nylon thread. Postoperative radiographs were performed (figure 3).

Fig 2: Photographic image of left humerus osteosynthesis in dog, mixed breed, 1 year old in the immediate postoperative period, evidencing the presence of the external fixator type I.

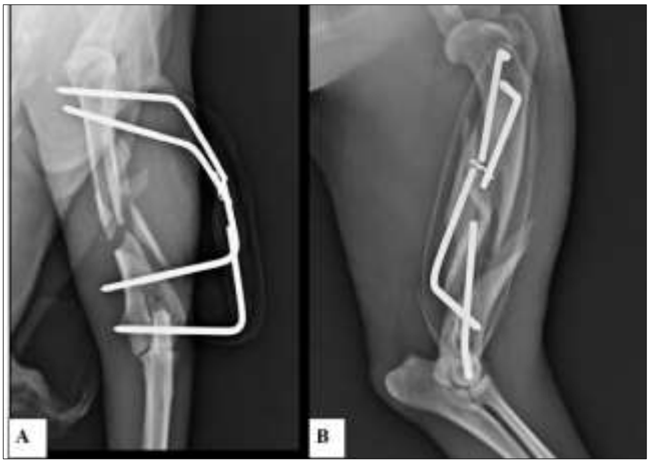

Fig 3: Radiographic images of the left humerus of the dog, mixed breed, 1 year, in the immediate postoperative period showing a comminuted fracture in the middle third, with the presence of the external skeletal fixator type I. In A, craniocaudal projection. In B, mediolateral projection.

Tramadol Hydrochloride (3 mg / kg, BID, 5 days), Dipyrone (25 mg / kg, BID, 5 days) and Cephalexin (30 mg / kg, BID, Kg, BID, 10 days) were prescribed as postoperative medications. As well as, the owner was advised to clean daily around the pins with povidone iodine. Within 15 postoperative days, the animal returned to the hospital to remove the stitches. The wound healed and the patient presented slight claudication with the support of the operated limb. After 30 days of surgery, the patient returned with good locomotion, with no clinical evidence of lameness. After 60 days of osteosynthesis, the patient was reevaluated and had good ambulation, with no clinical evidence of lameness, pain, instability, and crepitus of the operated limb. The presence of a smooth periosteal reaction in fragments of the fracture focus and the reduction of the space between the fragments was observed by x-ray, but a radiolucent line of fracture and bone axis deviation was still observed.

After 90 postoperative days, the fracture presented the remodeling of the bone callus (Figure 4), so the fixator was removed. The animal returned for reassessment after 9 months of the removal of the fixative. The patient was in perfect clinical and ambulatory conditions. A new radiographic examination was performed (Figure 5).

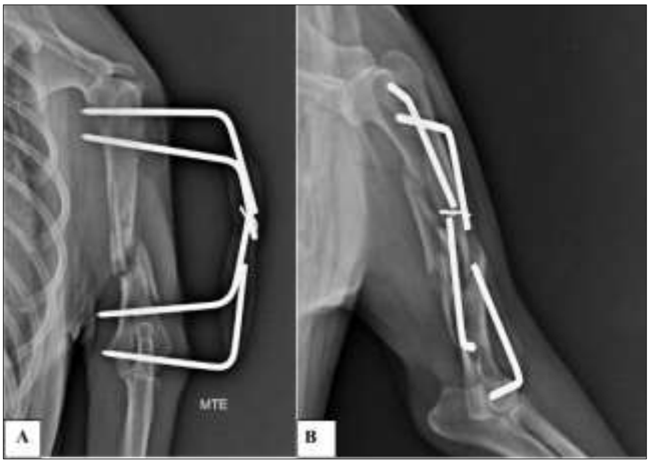

Fig 4: Radiographic image of the left humerus of the dog, mixed breed, 1 year, 90 days after the surgical intervention, there is an organization of the bone fragments, with reduction of the fracture focus. It is possible to observe the presence of the reconstructed bone callus formation with a discrete deviation of the bone axis. In A, craniocaudal projection. In B, mediolateral projection.

Fig 5: Radiographic image of the left humerus of the dog, mixed breed, 1 year, 9 months after the surgical intervention, we note the consolidation of the fracture with bone remodeling and absence of fracture line. In A, craniocaudal projection. In B, mediolateral projection.

Discussion

It is important to consider the anatomical aspects of the humerus, which is a complex form making your osteosynthesis a big challenge. The humerus has an "S" shape, with a large projection in the proximal region, where it is constituted by a strong and dense cortex in the cranial region. In the distal region, the humerus is straight, however, the epicondyles, medial and lateral, present ridges that make it difficult to model bone plates (Paulino, 2009) [17]. In addition, access to the humerus is hampered by the great muscular, vascular and nervous cover that surrounds the bone (Piermattei *et al.*, 2009; Tobias and Johnston, 2012.) [10, 18]. Thus, the placement of adjacent and shaped implants to the bone for anatomic reconstruction of the humerus is complex and external fixator is appropriate, as in the case in question (Fossum, 2015) [19].

The use of external fixators provides us with numerous advantages such as great variability of use; minimal tissue damage by preserving the periosteal and endosteal vascularization; possibility of closed application, preserving

the rich hematoma of the fracture focus; and low cost (Piermattei *et al.*, 2009; Tobias and Johnston, 2012; Fossum, 2015; Rezende *et al.*, 2006) [10, 18, 19, 20]. Due to these advantages, the external fixator was used in this case.
Among the most commonly observed complications with the use of external fixators is loosening of the pins, due to the numerous micromovements at the contact point between the pin and the bone or caused by thermal and mechanical lesions that occur at the time of implant placement (Johnson and Hulse, 2015) [2]. Other complications may be observed by poor fixation stabilization, resulting in non-union of the fracture. Poor management of external pins can also lead to bone infections causing local pain and bone resorption. In addition, it is possible to break pins leading to the mechanical instability (Corr, 2005) [21]. Fortunately, in the case in question, no such complications were observed.
In comminuted fractures, the excessive manipulation of small fragments may harm the vascularization then, causing the non-union of these fragments to the bone callus leading to the formation of bone sequestration (Rovesti, 2005) [22]. Thus, the minimum exploration of the fracture focus is fundamental for the success of these comminuted fractures, as occurred in this patient.
For a long time, it was believed that the manipulation of the fracture focus with the purpose of adjusting the bone fragments aiming at the original anatomical reconstitution would contribute positively to the osteosynthesis. However, with the advances obtained through current research, it is known that intervention in the focus of the fracture in an excessive way damages the adjacent soft tissues, degrades the bone and can lead to a poor consolidation (Gemmill, 2007; Schmierer and Pozzi, 2017) [23, 24]. Therefore, in this patient, we chose the use of closed osteosynthesis that preserves all the initial hematoma of the fracture and the rich neovascularization that already exists in the focus of the fracture, especially since it is an old fracture in which the animal organism already seeks a structural reorganization (Denny and Butterworth, 2006) [9].
According to Weisbrode (2007) [25], local instability, inadequate blood supply, and infection are possible complications observed in bone healing. Denny and Butterworth (2000) [26] add that excessive movement in fracture focus compromises angiogenesis and, consequently, blood supply to the site. In view of these complications, closed osteosynthesis has become the best option to subtract collateral damage from poor blood supply, since this technique promotes the preservation of the vascularization present in the fracture site from the initial hematoma.
Although the technique of biological osteosynthesis is recommended in recent fractures, in this case, due to the poor clinical condition of the patient occasioned by the concomitant ehrlichiosis, osteosynthesis was performed after 30 days of trauma; and even then, the results were very satisfactory. We hypothesize the success of osteosynthesis in this case was made possible by the great planning carried out preoperatively, evaluating not only the mechanical factors but also the biological and clinical factors to that the implant and the ideal application form to were selected. Among the relevant biological and clinical factors in this case we can include: the difficulty of reducing an old comminuted humeral fracture; the large size, the young age and the behavioral of the patient; the general good health after the treatment of the ehrlichiosis; the willingness and ability of owners to meet the postoperative needs of their animal (Fossum, 2015) [19].
Mechanical osteosynthesis, which reconstructs the bone anatomically, is useful in simple fractures such as transverse, oblique and spiral fractures, because in these fractures, with a small gap between the fragments, the strain is high and rigid implants are necessary to maintain stability in the fracture focus. In addition, the anatomical reconstruction of the bone column provides good load sharing with the implant, minimizing micro-movements of the fracture focus and increasing the resistance of the implants. On the other hand, the need for precise alignment of the fracture focus leads to greater iatrogenic vascular trauma (Peirone *et al.*, 2010) [27]. Thus, in comminuted fractures with low strain, in which greater micro-motion of the fragments is allowed, biological osteosynthesis is advantageous when compared to mechanics because, although it does not bring good burden-sharing by not reconstructing the bone, it minimizes damage to the soft tissue envelope during reduction and allows for greater maintenance of the vascular supply (Tobias and Johnston, 2012; Piórek *et al.*, 2012) [18, 28]. Stated that the biological osteosynthesis method is currently the best option for the treatment of some fractures, especially the comminuted fractures, since avoiding damage to the fracture focus, the results are closest to the physiological. Thus, we chose to use biological osteosynthesis even though it was an old fracture with a greater potential for complications.
It is worth mentioning that the biological osteosynthesis is a method that can be performed with instruments and implants common to the orthopedic surgical routine; however, it requires great anatomical knowledge by the surgeon, since it is necessary to maintain good alignment and adequate bone length without observing the focus of the fracture.

Conclusion
In this patient, it was possible to conclude that the application of external fixator in a closed manner allowed the fracture alignment without manipulation of the fragments, good bone healing and excellent return of the function of the limb even though it was an old fracture.

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