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Management of Elbow Luxation in Dogs and Cats: An Overview

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ABSTRACT:

Luxation of the elbow has been frequently reported in dogs and cats. It can occur in several forms lateral, medial, caudal luxation or Monteggia fracture. Several methods have been used for management of elbow luxation including closed or open reduction in combination with temporary joint immobilization. The later can be achieved via external coaptation, trans-articular pinning of external skeletal fixation. Although external coaptation is easy to apply and noninvasive, re-luxation, pressure sore, and decreased range of joint motion are the most reported complications. Transarticular pinning technique is simple based on fixation of the olecranon to the distal third of the humeral body. But it's invasive, requires excessive soft tissue dissection, and a second surgery for its removal. Transarticular external skeletal fixation can be applied to the elbow in the form of rigid, hinged, or elastic fixation. Such technique is minimally invasive, allow easy access to skin wounds, and most of the fixation devices maintained outside the body. However, pin tract infection, premature pin losing and/or breakage, and bone fracture are the most common associated complications. This report reviews current fixation techniques used for stabilization of the elbow and highlights the advantages and disadvantages of each technique.

Keywords: Cat, Dog, Elbow, External skeletal fixation and Luxation.

INTRODUCTION

Dogs and cats subjected to various form of musculoskeletal affections (Das et al., 2015; Jaeger and Wosar, 2018). Of which, joint luxation such as elbow and tarsal luxation are of the most important forms (Schwartz and Griffon, 2008).It is greatly affect animal performance causing severe lameness and, in many situations, may necessitate limb amputation (Valastro et al., 2005; Schwartz and Griffon, 2008). Several techniques were adopted for management of joint luxation including external coaptation, internal fixation and transarticular external skeletal fixation (TESF). External coaptation in the form of casts and splints is a non-invasive and easily applicable method can be used for management of different orthopedic problems. But it is poorly tolerated by the animal, often resulting in slippage of the bandage, and soiling. In addition, it hinder wound dressing and management, and frequently result in high rate of pressure sores and muscle atrophy (Chow & Balfour, 2012 &Williams et al., 2020). On the other side, Internal fixation is commonly used for management of joint luxation in dogs and cats such as talocrural instability or luxation. But it had several drawbacks in terms of, extensive soft tissue dissection resulting in excessive tissue trauma and blood loss, lengthen the operation time and recovery period, increased post-operative pain, andit requiresa second operation for implant removal. Besides, the complex anatomical conformation of the affected site in many situations made perfect contouring of the implant is difficult which necessitate direct application of the implants to the bone resulting in retardation of the healing process. Along with, implant deformation or loosening and failure, iatrogenic bone fracture, pressure sores are another drawbacks for this technique (Schwender et al., 2006 & Corr et al., 2010). The aim of thisarticle is to highlight different techniques used for management of elbow luxation in dogs and cats including its reported advantages and disadvantages.

1. ***Elbow joint,anatomy, and surgical affections:***

The elbow joint is composed between the distal end of the humerus and proximal ends of radius and ulna. It consists of humero-ulnar joint between humeral condyles and the trochlear notch of the ulna, humero-radial joint between humeral condyles and the head of the radius, and proximal radio-ulnar joint between the ulnar notch of the radius and radial circumference of the ulna (Budras et al., 2007). The elbow joint gains its stability from its anatomical characterization via the interlock of the anconeal process into the olecranon fossa, its surrounding muscles, and the ligamentous support (Bordelan et al., 2005 & Mitchell, 2011).The ligamentous support of the elbow joint is composed of medial and lateral collateral ligaments, annular and interosseus ligaments. The medial collateral ligament originates at the medial humeral epicondyle anddivided into cranial and caudal portions. The cranial portion inserted proximal to the radial tuberosity and the caudal portion inserted at the proximal ulna. The lateral collateral ligament originate at the lateral humeral epicondyle and divided into cranial part that inserted distal to the radial neck and caudal part that attached to the ulna (Evans & Lahunta, 2013). Comparing to dogs, cats have a longer and wider collateral ligaments (Engelke et al., 2005 & Bordelan et al., 2005). The annular ligament spans between the lateral and the medial extremities of the radial notch of the ulna and surrounding the radial head (Evans and de Lahunta, 2013). The interosseus ligament connects the radius to the ulna at the proximal half of the interosseus space between the radius and ulna (Krotscheck et al., 2014).

Luxation of the elbow has been frequently reported in dogs and cats. It can be congenital or traumatic. The congenital form has been reported at birth or three to four months later. It is generally observed in small breed dogs (Milton and Montgomery, 1987; Rahal et al., 2000 ; McDonell, 2004 & Valastro et al., 2005). Traumatic luxation of the elbow has been reported in mature animals above one year old. It mostly occur as a result of traffic accidents, limb entrapment, failing from height, or indirect rotational forces (Schaeffer et al., 1999 & Bongartz et al., 2008).

Luxation of the elbow can be lateral (Bordelan et al., 2005; Farrell et al., 2007; Mitchell, 2011 & Logothetou et al., 2022), medial (Mitchell, 2011 & Sasaki et al., 2020) or caudal (Hamilton et al., 2014). Lateral luxation of the elbow is most common type. This was attributed to the anatomical characterization of the joint in which the medial humeral epicondyle is larger compared to the lateral one.

Moreover, the lateral collateral ligament is stronger, larger and containing more collagen bundles comparing to the medial one which favors luxation of the joint to the lateral aspect (Kochet al., 2005; Güzel et al., 2006& Sajiket al., 2016). Clinically, luxation of the elbow has been represented in different forms; it may occur while the radio-ulnar joint remains intact or disrupted. It may also include the humero-ulnar joint or presented as Monteggia fracture in which the luxated radial head accompanied with proximal ulnar fracture (Voss et al., 2009). The latter may take one of the following four clinical forms. Type I, in which the radial head luxated cranially. In type II, the radial head luxated caudally. In type III, the radial head luxated laterally. And in type IV, the luxation occur as a result of fracture of the ulna and the proximal radial diaphysis (Schwarz & Schrader, 1984).

2. Surgical management:

Surgical management of the luxated elbow can be accomplished via closed or open reduction in combination with temporary joint immobilization (Bordelan et al., 2005 & Bongartz et al., 2008). Open reduction is recommended in cases of chronic luxation, cases that showed marked instability or re-luxation after closed reduction, in cases of avulsion fracture at the insertion of the collateral ligament, or in case of intra-articular fracture (Mitchell, 2011& Krotscheck and Böttcher, 2018). Open reduction could be accompanied with primary suture in a locking loop pattern (Mitchell, 2011; Krotscheck & Böttcher, 2018), lag screw fixation with spiked washer when luxation accompanied with avulsion fracture at the ligament origin (Mitchell, 2011), tension band wire, or via suturing of the annular ligament and its surrounding fibrous tissue (Krotscheck & Böttcher, 2018). When primary ligament suture couldn't be applied, ligament replacement techniques often be used to enforce the primary suture or as a sole repair technique (Farrell et al., 2007).

Collateral ligament replacement can be carried out via bone anchoring, bone tunnels, or by using screws in combination with suture material. In the later technique, two screws were used, one is fixed at the humeral condyle and the other at the radial head. Both screws are fixed together with wire or suture materials in an eight-figure loop. Although this technique provide strong bone to bone attachment, soft tissue irritation from screws and wire with swelling, seroma, local pain and discharge were observed (Güzel et al., 2006; Voss et al., 2009; Mitchell, 2011 & Sağlam et al., 2020). In bone anchor technique, the ruptured ligament is anchored through the humeral epicondyle using polydioxanone. Although it provide a satisfactory result, separation of the ligament from the anchor has been reported (Logothetou et al., 2022). In bone tunnels technique, the luxated bones are fixed together using circumferential suture repair through three bone tunnels. The first one at the humeral trans-condyles, the second at the radial head and the third at the mid-portion of ulnar trochlear notch (Hamilton et al., 2014). The authors reported that such technique can be used as a sole treatment for management of the luxated elbow moreover, it can overcome complications associated with immobilization. The main disadvantages of this technique are its technical difficulty and knot slipping (Farrell et al., 2007 & 2009).

Temporary immobilization of the elbow for 2-3 weeks after its reduction is the key point for completion of the healing to the luxated joint and to overcome complications associated with long term of immobilization. The treated joint should be maintained in an extension position to a degree that allows anconeal process to sit in the olecranon fossa and prevent vits lateral or medial luxation (Krotscheck & Böttcher, 2018).

Several studies have been carried out over the past three decades to detect the most appropriate method for temporary immobilization of the elbow after its reduction. The elbow can be stabilized by external coaptation (Robert Jones bandage or Spica splint) (Güzel et al., 2006; Mitchell, 2011), transarticular pinning (Rahal et al., 2000), or by external skeletal fixation (Schwartz & Griffon, 2008; Farrell et al., 2009). Several drawbacks have been reported after the use of external coaptation including re-luxation, bandage complications and decreased range of joint motion. besides, this technique can't be tolerated by most cats (Meeson et al., 2011; Krotscheck & Böttcher, 2018; Williams et al., 2020). In transarticular pinning, a screw was fixed through the middle third of the caudal aspect of the olecranon tuberosity to the distal third of the humeral body. Although this technique is simple, a high rate of re-luxation has been reported. Moreover, it require excessive soft tissue dissection, and a second operation is required to remove the implant (Rahal et al., 2000).

In ESF, the majority of the fixation devices remains outside skin surface. It consisted of a series of percutaneous pins that penetrate both bone cortices and connected to each other by external connecting bar. It has been used for the treatment of open, comminuted or complex fractures, luxation, ligaments and tendons shearing injuries (Palmer, 2012 & Jaeger and Wosar, 2018)**.** The first clinical representation of ESF in veterinary practice was in the form of Stader splint that has been performed by Otto Stader in 1937. By 1940s Kirschner-Ehmer (KE) system was introduced to the veterinary field. It provided greater advantage compared to the former one, in terms of easiness of pins angulation at its insertion. In 1984, Ilizarov has recorded the first use of a circular external skeletal fixator (Ilizarov system) in veterinary practice (Gemmill, 2016).

There are different types of ESF devices exist today, including linear (traditional), circular, hybrid, and acrylic (free) forms. The linear form is composed chiefly of fixation pins, connecting clamps, and connecting bars. The circular form consisted of fixation pins or Kirschner wires and the clamps were replaced by bolts and rings that connected to each other by connecting bars. The hybrid form is a combination between the linear and the circular forms. While, the acrylic form differed from the linear form in which the stainless-steel clamps and the connecting bars were replaced by acrylic bar (Aron et al., 1986; Anderson et al., 1993; Makarov et al., 2001; Bruce et al., 2008; Silva et al., 2012; Hudson et al., 2012). The linear and the acrylic ESF frames are used for management of long bone fracture, joint and vertebral luxation (Jaeger et al., 2005; Wheeler et al., 2007 & Hamilton et al., 2014). The circular ESF frames are used chiefly in the treatment of limb deformity by distractive osteogenesis. It provides micro motion between the fractured ends that stimulate the healing process (Stalling et al., 1998 & Lewis et al., 2001). The hybrid ESF combines the advantages of both linear and circular frames, it combines static axial stiffness of linear ESF and the micromotion of the circular one. It is easy to apply and effective in stabilization of small bone segments (Kirkby et al., 2008; Hudson et al., 2012) It constitute theideal stabilization method for treatment of juxta-articular fracture of humerus or femur and the distal angular limb deformities (Halling et al., 2004).

According to the number and plansat which the connecting bars are fixed, the linear ESF frames can be uniplanar, biplanar or multiplanar (Roe, 1992). In uniplanar frames, the pins were placed at one plane, while in biplanar the pins were placed in two perpendicular planes. In multiple planar, pins were placed in multiple planes (Jaeger and Wosar, 2018). Marti and Miller, (1994) have established different zones for pin placement for each bone and classify these zones into safe, hazardous, and unsafe zones. They recommended placing the pin at the safe zones which referred to the anatomic region of the bone that is relatively devoid of neurovascular structures and minimal soft tissue coverage. According to pin arrangement in relation to the bone, ESF can be categorized into type I, II, III, and hybrid form or combination between each of them. Type I (unilateral), in which the pins are arranged and placed at one side of the bone. It may be unilateral uniplanar (type Ia) or unilateral biplanar (type Ib). Type II (bilateral) ESF frame, in which the pins pass both cortices of the bone and connected from either side with connecting bar. It may be bilateral uniplanar with full pins, bilateral uniplanar with combination of full and half pins (modified type II). Type III (bilateral biplanar), in which the pins passed both bone sides, placed in a perpendicular plan and connected at either side with a connecting bar. The hybrid form is a combination between type I and II (Jaeger and Wosar, 2018). The more complex (type II and III) frame provides more strength and stiffness properties that can overcome shearing, axial and torsional forces than simple frame (Cross et al., 1999 & White et al., 2003; Bronson et al., 2003; Amsellem et al., 2010).

In all types, the fixation pins are formed from smooth or threaded stainless steel rods. The threaded pins may be positive or negative profile, center face (full) or interface (half, or called end threaded) pin (Clary and Roe, 1995&Sandman et al., 2002).In case of center face threaded pins, the pins penetrates skin and soft tissue at both sides of the bone with the threaded part engaged to the bone leaving two ends for attachment of the connecting bars. In case of interface pin, the pins penetrate skin and soft tissue of only one side while fixed to both cortexes of the bone leaving only one end for attachment of the connecting bar (Jaeger and Wosar, 2018). The connecting bars have several types. It formed form rods of stainless steel, carbon fiber, titanium, or aluminum. The reported drawbacks of the traditional calp-and-rod system are difficulty of its modulation, hindrance of post-operative mediolateral radiographic assessment, its bulkiness, and overweight which turns out to be cumbersome for the animal, they also limited for specific pins and clamps size (Kraus et al., 1998; Kraus and Wotton, 1998; Toombs et al., 2003; Bronson et al., 2003; White et al., 2003; Owen ,2000; Kulendra et al., 2011 & Hammer et al., 2020).

To overcome the aforementioned draw backs, the ordinary metallic clamps and connecting bars are replaced by acrylic components (methyl metaacrylate or epoxy) (Acrylic external skeletal fixator or called free form external skeletal fixator) (Roe and Keo, 1997 & Davis et al., 1998). It is light, strong, economic, and has smooth edges that makes it more tolerated by the animal without injury of adjacent soft tissues (Shani and Shahar, 2002). Moreover, it is easily moldable allowing adequate joints fixation. It can fit to variable pin sizes, and allow free pin placement at any plane and angle that maximize using the safe zones of the bones. It's also radiolucent allowing postoperative radiographic evaluation (Reaugh et al., 2007; Shahar, 2000; De La Puerta et al., 2008 & Amsellem et al.,2010). On the other hand, the frame cannot be reconfigured after being hardened, and the produced heat during its setting may result in thermal injury to the adjacent soft tissues and bone (Ross And Matthiesen, 1993; Martinez et al., 1997; Williams et al., 1997; Amsellem et al., 2010).

Transarticular external skeletal fixation (TESF) has been used for stabilization of periarticular structures and prevent or eliminate joint movement in case of joint luxation or instability. It can be used alone or combined with different internal repair techniques for temporary stabilization of the elbow till healing of the injured tissue took place (McLaughlin and Tillson, 1994; Bruce, 1999; Schwartz and Griffon, 2008; Hammer et al. 2020). For elbow stabilization, TESF can be applied in the form of conventional type Ia, II, orhybrid form (Jaeger and Wosar, 2018). In type I, five to seven end threaded pins are used. Two to four are fixed at the humerus and two to three are fixed at the radius. In type II, two center threaded pins are used, one is fixed at the distal humerus and the other at the olecranon. The hybrid form is a modification of type II, in which an extra end threaded pin is used and fixed at the distal humerus. After its driven, the pins are fixed to each other via rigid bar (rigid frame), hinged bar (hinged frame), or elastic band (elastic frame or nonrigid) (Jaeger et al, 2005, Schwartz et al., 2008). The rigid frame provide stabilization efficient for healing of the concomitant orthopedic problems, while on the long run (more than four weeks), its use may resulted in several complications such as Joint stiffness, muscle atrophy, and decrease in the range of joint motion (Mitchell, 2011 & Hamilton et al., 2014).To over the aforementioned complications resulted from joint rigid fixation, the hinged and the elastic frames are developed. In the hinged frame, the connecting bar is supported with hinge at the level of the joint to provide stabilization and allowa controlled joint motion in a single plane. It allows the physiological load of the ligaments, tendons, and peri-articular soft tissues to relieve the adverse effect of complete immobilization (Jaeger et al., 2005). On other hand, perfect adjustment of the hinge should be accomplished, otherwise cartilage damage will be its major complications.(Bruce et al., 2005). In the elastic (nonrigid) frames, the pins are fixed rigidly for two days then the rigid bar is replaced by elastic band. Such kind of frames allows joint motion within its normal limits (Schwartz et al., 2008). However, pin tract infection, premature pin loosing and/or breakage, fracture of the olecranon, deterioration of the plastic band and skin irritation are the most common associated complications (Schwartz & Griffon, 2008; Vedrine, 2017 and Krotscheck & Böttcher, 2018).

CONCLUSIONS

In conclusion, this article can provide valuable insights into elbow luxationas one of the major musculoskeletal affections in dogs and cats. It also highlighted different surgical management techniques used for stabilization of the luxated elbow. Of which rigid transarticular external fixation constitutes the most appropriate fixation technique for temporary stabilization of the elbow taking into account not to prolong the fixation period over than three weeks.

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