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TREATMENT OPTIONS FOR CRANIAL CRUCIATE LIGAMENT RUPTURE IN DOG – A LITERATURE REVIEW

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Abstract

Cranial cruciate ligament (CrCL) breaks in dogs can be treated by surgical and non-surgical methods. Choice of the treatment method of cranial cruciate ligament rupture in dog continues to constitute a real problem for veterinarian clinicians. This topic has been the subject of many studies. The investigation of the speciality literature data concerning the surgical treatment options in the management of cranial cruciate ligament breaks in dog, remains in the conditions of an informational avalanche a present concern. The purpose of this study was to analyze additional evidence which have appeared in the literature in the period of 2006 - January 2017 and which advocate with concrete evidences in the favour or disfavour of a particular method of dog's cranial cruciate ligament breaks treatment. Analysis of online searches using PubMed engine in 403 articles suggest that the data analyzed do not allow accurate comparisons between different treatment procedures of cranial cruciate ligament deficiency in dogs and did not show significant differences and major changes compared to previous reports (from 1963 to 2005). New long-term clinical studies must designed and further biomechanical and kinematic analyses are required to determine the optimal technique, and whether these procedures are superior to other stabilization methods.

Key words: *cranial cruciate deficiency, dog, treatment procedures, trend.*

INTRODUCTION

Choice of the treatment method of cranial cruciate ligament (CrCL) rupture in dog continues to constitute a real problem for veterinarian clinicians.

This topic has been, since 1963 (Foster et al., 1963), the subject of many concerns and studies. CrCL breaks in dogs can be treated by surgical and non-surgical methods.

The latest study investigating the speciality literature on surgical treatment options in the management of CrCL ruptures in dogs was published in 2005 (Aragon and Budsberg, 2005) after an online bibliographic search through Medline, PubMed, Veterinary Information Network, and Commonwealth Agricultural Bureau Abstracts were found and analyzed 240 sources and it ends with the conclusion „*At this time, the application of evidence-based medicine in analyzing the current available evidence suggests that there is not a single surgical procedure that has enough data to recommend that it can consistently return dogs to normal function after CCL injury*".

Referring only to the surgical procedures used to treat dog's CrCL ruptures, a review from 2011 (Tonks et al., 2011) was focused only on extracapsular procedures and shows that there is no data to allow recommendation of a specific technique being necessary „*future studies should be directed toward outlining the virtues and inadequacies of the current techniques"* and another study investigating the literature (444 paper works) with constant referring only on surgical procedures occurred in 2014 (Berg et al., 2014) conclude that tibial plateau levelling osteotomy (TPLO) is superior to the extracapsular lateral side suturing procedures, but there are insufficient data to properly assess other surgical methods.

There are also several studies comparing the effectiveness of surgical and non-surgical therapeutic methods, the latest being dated in 2013 (Baker and Baker, 2013; Comerford et al., 2013; Wucherer et al., 2013).

The purpose of this study was to analyze additional proof which have appeared lately in the speciality literature in the favour / disfavor of a particular method of CrCL breaks treatment in dog.

MATERIALS AND METHODS

In January 2017 was conducted an online search, using three searching engines: Google scholar (https://scholar.google.ro), PubMed – US National Library of Medicine National Institutes of Health (https://www.ncbi.nlm.nih.gov/pubmed) and Taylor & Francis Online (http://www.tandfonline.com).

There have been used as basic search term "cranial cruciate ligament rupture in dog" preceded into three main additional insights by the terms „treatment", „nonsurgical treatment", „surgery treatment", last with the following secondary insights „lateral extracapsular stabilization treatment", "tibial plateau levelling osteotomy - TPLO", " tibial tuberosity advancement - TTA", " triple tibial osteotomy - TTO" and "Maquet".

Filtering of the results was done using „most recent" and „best match" for PubMed engine, „article" for Google scholar and „subject" and „publication date" for Taylor & Francis Online.

The results obtained by investigating PubMed were analyzed and classified according to the method proposed by Aragon and Budsberg, 2005, after the evaluation method used: 1 - force plate analysis, 2 - subjective and objective evaluation by the clinician and 3 - subjective evaluation by the pet owner, being considered relevant in this order (1 – maximum and 3 - minimum).

RESULTS AND DISCUSSIONS

Results of the bibliographic online introspection are shown in Table 1.

The analysis of search results with PubMed engine reveals 403 articles (for the period 1963 - January 2017), respectively 391 after manual excluding of those in whose abstract was not evidenced a connection with CrCL. In the period 2006 - January 2017 were found 216 articles about CrCL in dog, data that reveals a near doubling of number of articles reviewed by Aragon and Budsberg until August 2004 (Aragon and Budsberg, 2005).

In the period of 2006 - January 2017 have appeared instead only 115 articles for therapeutic results evaluation of dog's CrCL ruptures from which only 23 were relevant articles of level 1, according to the criterion (evaluation by force plate analysis), 86 articles of level 2 (subjective and objective evaluation by the clinician) and 6 articles of level 3 (subjective evaluation by the pet owner).

Table 1. Number of scientific papers identified online

Descriptors	Search engines		
	Google scholar (https://scholar.google.ro)	PubMed – US National Library of Medicine National Institutes of Health https://www.ncbi.nlm.nih.gov/pubmed)	Taylor & Francis Online (http://www.tandfonline.com)
cranial cruciate ligament rupture in dog	10.600	403	62
treatment cranial cruciate ligament rupture in dog	9550	267	51
surgery treatment cranial cruciate ligament rupture in dog	8530	251	41
lateral extracapsular stabilization treatment in cranial cruciate ligament rupture in dog	735	5	2
tplo treatment in cranial cruciate ligament rupture in dog	983	33	4
tta treatment in cranial cruciate ligament rupture in dog	465	21	1
tto treatment in cranial cruciate ligament rupture in dog	384	3	1
tightrope in cranial cruciate ligament rupture in dog	140	4	0
maquet procedure in cranial cruciate ligament rupture in dog	162	3	0
bone anchor in cranial cruciate ligament rupture in dog	1340	3	20
nonsurgical treatment in cranial cruciate ligament rupture in dog	1120	3	1

Of the 23 articles of level 1, six articles promotes kinematics and force plate analysis methods for the diagnosis of dog's CrCL ruptures (Fanchon and Grandjean, 2007; Sanchez et al., 2010; Pillard et al., 2012; Nelson et al., 2012; Souza et al., 2014; Krotscheck et al., 2014; Wüstefeld et al., 2016), 14 articles describe or compares the results obtained with different techniques of surgical treatment (Thieman et al., 2006; Robinson et al., 2006; Havig et al., 2007; Schaijk, 2008; Voss et al., 2008; Gordon-Evans et al., 2010; Pozzi et al., 2010; Morgan et al., 2010; Gordon-Evans et al., 2011; de Medeiros et al., 2011; Böddeker et al., 2012; Nelson et al., 2012; Mols et al., 2014; Rey et al., 2014; Berger et al., 2015) and two articles describe and compares the results obtained with different nonsurgical treatment techniques versus surgical (Siva et al., 2013; Wuchereria et al., 2013).

If in 2005 there is the opinion that a correct assessment of effectiveness of dog's CrCL rupture treatment method only the investigations of level 1 can be considered reliable (Aragon and Budsberg, 2005; Houlton, 2013), reaffirmed subsequently (Fanchon and Grandjean, 2007; Sousa et al., 2014; Wüstefeld et al., 2016) there are some studies appeared quite recently (Mols et al., 2014) which concludes that „*ground reaction forces may be inadequate as a sole method for assessing functional outcome after cranial cruciate ligament repair*".

Articles of level 2, for the most part, makes the inventory of postoperative complications of different treatment's types (Butterworth and Kydd, 2017; Dymond et al., 2010; Fitzpatrick and Solanio, 2010; Frey et al., 2010; Haaland and Sjöström, 2007; Hishenson et al., 2012; Imholt et al., 2011; Rotherford et al., 2012; Stauffer et al., 2006; Proot and Cooke, 2009; Taylor et al., 2011; Thompson et al., 2011; Wolf et al., 2012; Moles et al., 2009) or shows mixed results of level 2 with 3 (Christopher et al., 2013; Stein et al., 2008; Steinberg et al., 2011).

The estimated costs of surgical treatment for cranial cruciate ligament ruptures in dogs in USA in 2003 were 1.32 billion dollars (Wilke et al., 2005).

Surgical techniques for the repair of cranial cruciate ligament deficiency can be classified into three categories: intra-articular grafts, extracapsular suture stabilization and proximal tibial osteotomy (Hulton, 2013).

Intraarticular stabilization techniques utilize autografts, allografts, xenografts, and synthetic materials to replace the affected CrCL (Paatsama, 1952; Leighton et al., 1976; Arnoczky et al., 1979; Hulse et al., 1980; Meyers et al., 1979; Andnsh and Woods, 1984; Curtis et al., 1985; Yoshiya et al., 1986; Yoshiya et al., 1987; Vasseur, 1984; Stead et al., 1991; Aiken et al., 1994; Tonks et al., 2011).

Vasseur, 2003, makes the inventory of the main reasons of intra-articular procedures low use: - autografts present inferior stiffness and strength compared with normal ligament; - allografts present the inconvenience of collection and storage; - synthetic materials caused intra-articular fibrosis, bone abrasion and chronic inflammatory response; which has limited their use in veterinary medicine.

Extra-articular stabilization techniques include: lateral fabellar suture (LFS), percutaneous placement of the lateral fabellar suture (pLFS), Tightrope (TR) (Cook et al., 2010), transcondylar toggle system (Kunkel et al., 2009), modified lateral extra-capsular technique with bone anchor.

The treatment using lateral fabellar suture (LFS) remains at this moment the most practiced method, applied particularly in small dogs (Hulton, 2013).

The major shortcoming of the method (overloading of suture anchor points) (Fischer et al., 2008) has benefited from the contribution of several studies (Roe et al., 2008; Hulse et al., 2010; De Sousa et al., 2014; Cinti, 2015) which introduced the concept of anchoring in isometric position (relatively isometric) but also the anchor through bone anchors (Guenego et al., 2007; Hulse et al., 2011; Choate et al., 2012; Rask et al., 2013; Citi, 2015).

Efforts to identify the ideal material for suture when lateral fabellar suture is applied were materialized by the dethronement of nylon wires as the main option (Caporn and Roe, 1996; Lewis et al., 1997; Sicard et al., 2002; Sicard et al., 2012; Ledecky et al., 2012; Igna et al., 2014) and by promoting polyethylene wires which are stronger, stiffer and elongate less than nylon leader (Burgess et al., 2010; Tonks et al., 2010; Choate et al., 2012), promising options offers the polyblend wires (Rose et al., 2012) and braided polyester (Guenego et al., 2007).

Securing of the suture reveal the existence of three systems: a square knot (SQ), a slip knot (SL) and a crimp clamp (CR).

Existing data show no new information being maintained the recommendation (Nwadike et al.,1998) "*that 27-kgt nylon leader line be secured with a SL, and 27-kgt nylon fishing line be secured with a SQ*" as the "*clamping the first throw of a square knot in monofilament nylon leader material who increases failure load by two percent and stiffness by 16%, and decreases elongation by 12%*" (Caporn and Roe, 1996) although there are studies showing that "*crimping suture alters the biomechanical properties of the loop*" (Burgess et al., 2010). Securing the suture through CR remains a superior method of knotting techniques (Anderson et al., 1998; Vianna et al., 2006) and the *wave pattern crimp system* is more efficient then the *single crimp system* (Maritato et al., 2012). Using tensioning sutures systems before the applying of a crimp clamp does not bring significant advantages over manual tightening (Moores et al., 2006).

Difficulties in various procedures execution are reported to be the bone tunnels creation in TR and anchoring around fabella in LSF and pLSF (Biskup and Griffon, 2014).

Evaluation of extracapsular therapeutic methods efficiency although it is the subject of several studies (Moore et al., 1995; Jevens et al., 1996; Caporn and Roe, 1996; Anderson et al., 1998; Budsberg et al., 1998; Conzemius et al., 2005; Guenego et al., 2007; Kunkel et al., 2009; Cook et al., 2010; Hulse et al., 2011; Havig et al., 2007; Schaijk, 2008) with mostly positive reports, many of these studies are subjective (level 2 and 3). Studies based on analysis of data obtained through force plate measurements show that peak vertical force was 93% and vertical impulse was 96% of normal values in the limbs of dogs that had extra-articular stabilization at six months following surgery (Conzemius et al., 2005), recorded differences being insignificant compared to normal preoperative values in all studies which appeared before 2006 (Jevens et al., 1996; Budsberg et al., 1998) and after (Havig et al., 2007; Schaijk et al., 2008).

Postoperative complications reported after the application of extra-articular stabilization techniques are between 4.2 and 17.4% (Casale and McCarthy, 2009; Frey et al., 2010) and a 7.2% of them required reintervention (Casale and McCarthy, 2009).

Proximal tibial osteotomy techniques include: tibial plateau levelling osteotomy - TPLO, combined tibial plateau levelling osteotomy and tibial tuberosity transposition (TPLO-TTT), tibial tuberosity advancement – TTA with the variants TTA-1, TTA-2 and TTA-rapid, triple tibial osteotomy - TTO and modified Maquet procedure – MMP.

All procedures impart primarily change the biomechanics of the stifle and required specialized and custom equipments. The choice of source of this equipment depend of surgeon preferences or/and their affiliated a product companies (Igna, 2013).

Recent assessments of the effectiveness of therapeutic methods of tibial osteotomy reveals unanimously that locomotor function of the limb with CrCL insufficiency can be improved using the techniques of tibial osteotomy (Bruce et al., 2007; Kim et al., 2008; Dymond et al., 2010; Schaijk, 2008; Christopher et al., 2013; Nelson et al., 2013) described so far (Slocum and Devine, 1984, 1993; Slocum, 1996; Leonard et al., 2016; Montavon et al., 2002; Maquet, 1976; Samoy et al., 2014; ***, 2012; Damur et al., 2003).

More prospective and retrospective studies (Pacchiana et al., 2003; McCarthy, 2002; Priddy et al., 2003 ; Carrey et al., 2005; Staufer et al., 2006; Bruce et al., 2007; Haaland and Sjöström, 2007; Lafavere et al., 2007 ; Stein et al., 2008; Voss et al., 2008; Duerr et al., 2008; Proot and Cooke, 2009; Moles et al., 2009; Dymond et al., 2010; Fitzpatrick and Solano, 2010; Frey et al., 2010; Conkling et al., 2010 ; Imholt et al., 2011; Taylor et al., 2011; Thompson et al., 2011; Gatineau et al., 2011; Coletti et al., 2011; Steinberg et al., 2011; Etchepareborde, 2011; Hishenson et al., 2012; Rotherford et al., 2012; Wolf et al., 2012; Christopher et al., 2013; Etchepareborde, 2014; Butterworth and Kydd, 2017) reports one or more complications (osteomyelitis, incisional infections, fractures of the tibia or fibula, broken drill bits, hemorrhage, intra-articular implant placement, intra-osteotomy screw placement, retained surgical sponges, broken holding pins or screws, septic arthritis, loose implants, draining tracts, ring sequestrum, incisional inflammation, dehiscence and swelling, osteomyelitis, oedema and seroma formation, bruising, premature staple removal, patellar tendon swelling, and late meniscal

injury) after proximal tibial osteotomy procedures.
In TPLO postoperative complication rate, until 2006, ranged between 45.7 and 28% (Carrey et al., 2005; Pacchiana et al., 2003; McCarthy, 2002; Priddy et al. 2003) compared to 22.2-8.4% after 2006 (Staufer et al., 2006; Stein et al., 2008 ; Duerr et al., 2008 ; Imholt et al., 2011 ; Fitzpatrik and Solano, 2010; Frey et al., 2010; Conkling et al., 2010; Gatineau et al. 2011, Coletti et al., 2011) and 4.8% of the cases requiring implant removal (Thompson et al., 2011).
In TTA, the method introduced in practice in 2002 (Montavon et al., 2002), postoperative complication rate was between 35.5% and 11% (Lafavere et al., 2007 ; Voss et al., 2008; Hurt et al., 2009 ; Dymond et al., 2010, Steinberg et al., 2011, Hirshenson et al., 2012; Wolf et al., 2012) with 5.2% reinterventions (Wolf et al., 2012).
In TTO postoperative complication rate was between 18% and 23% (Renwick et al., 2009; Moles et al., 2009).
For MMP two complications were documented (subsequent meniscal injury) from a series of 12 cases (Etchepareborde et al., 2011; Etchepareborde, 2014) and 10.8% postoperative complications with 3.1% reintervention in a series of 65 cases (Bruce et al., 2007).
Comparative analysis of the obtained data (2006-2007) which assess the therapeutic efficiency by force plate measurements or kinematic data between extra-articular stabilization methods and tibial osteotomy methods (Schaijk, 2008; Nelson et al., 2012; Boddeker et al., 2012; Mols et al., 2014; Berger et al., 2015) as well as between different methods of tibial osteotomy (Lee et al., 2007; de Medeiros et al., 2011; Rey et al., 2014) does not show significant differences between methods and no major changes compared to previous reports.
Non-surgical treatment methods include administration of non-steroidal anti-inflammatory drugs, weight control, restriction of spontaneous locomotion, physiotherapy including hydrotherapy (Baker and Bake, 2013; Comerford et al., 2013; Wuchereria et al., 2013). These methods are usually applicable to small dogs with a body weight below 15 kg (Comerford et al., 2013).
In the treatment of obese dogs with ruptured CrCL surgical methods had a success rate (was defined as an affected limb net ground reaction force > 85% of the value for healthy dogs and a ≥ 10% improvement of the initial values) at 52 weeks after surgery by 75% compared to 63.6% in those treated by non-surgical methods (Wuchereria et al., 2013). The data presented are similar to those of previous studies, based only on clinical examination and with a success rate of 85.7% reported for small dogs with body weight below 15 kg (Vasseur, 1984).
Latest data concerning non-surgical methods of treatment (Baker and Bake, 2013; Comerford et al., 2013; Wuchereria et al., 2013) and veterinarians options for these therapeutic modalities (Comerford et al., 2013) did not show a change in trend compared to previous reports (Korvick et al., 1994), the majority of doctors preferring surgical approaches.

CONCLUSIONS

Currently available data does not allow accurate comparisons between different treatment procedures of cruciate cranial deficiency in dogs.
New long-term clinical studies must designed and further biomechanical and kinematic analyses are required to determine the optimal technique, and whether these procedures are superior to other stabilization methods.

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