CONSERVATIVE MANAGEMENT OF CRUCIATE LIGAMENT DEFICIENCY WITH PHYSICAL THERAPY

Laurie Edge-Hughes, BScPT, MAnimSt(Animal Physiotherapy), CAFCI, CCRT
The Canine Fitness Centre Ltd, Calgary, Alberta, Canada

Presented at the 5th International Symposium on Rehabilitation and Physical Therapy in Veterinary Medicine, St. Paul, Minnesota, 2008.

All practitioners involved in small animal health care are well aware of the fact that some animals are not surgical candidates, either due to age, poor health, an inadequate state of fitness, and/or because of financial constraints, or owners' beliefs. This subset of patients deserves a chance at optimal function as much as those that are prime surgical candidates with owners willing and able to bear the financial burden of surgery.

The Cruciate-Deficient Canine Stifle

The cranial cruciate ligament functions to prevent excessive cranial translation of the tibia relative to the femur as well as limiting internal rotation of the tibia.(Hulse 1995) In dogs, the mechanism of injury resulting in a ruptured cranial cruciate ligament (RCCL), can be from a single incident if the breaking strength of the ligament is exceeded.(Johnson & Johnson 1993) However, other dogs suffer from a RCCL with only mild trauma.(Moore & Read 1996) Etiology in the latter group of patients is suggestive of daily mechanical wear, and degenerative changes as well as unsuccessful attempts at biological repair have been reported in the fibres of the RCCL.(Vasseur 1985; Krayer et al 2008) Wilke et al 2006 was also able to establish a genetic basis for RCCL in Newfoundland dogs, and others have found a high prevalence of RCCL in this breed as well as Rottweilers and Staffordshire Terriers.(Whitehair et al 1993) Additionally, a breed predisposition was detected for Neapolitan Mastiff, Akita, Saint Bernard, Mastiff, Chesapeake Bay Retriever, and Labrador Retriever.(Duval et al 1999) Neutered dogs, whether male or female, had a higher prevalence of RCCL than did sexually intact dogs, and dogs weighing > 22kg had a higher prevalence of RCCL and at a younger age compared with dogs weighing < 22 kg.(Whitehair et al 1993) Obesity has also been reported as a contributing factor.(Johnson & Johnson 1993)

In the case of cruciate-deficiency, the stifle of the canine patient exhibits an increase in synovial macrophage density, and synovial fluid biomarkers of cartilage disease (i.e. osteoarthritis). (Innes et al 1999; Johnson et al 2002; Klocke et al 2005; Spreng D et al 2000) The chronology of degenerative events in the cruciate-deficiency follows through the stages of cartilage fibrillation, periarticular hypervascularity, osteophyte development, medial joint swelling, periarticular fibrosis (restabilization), meniscal injury, peak osteophyte formation and synovitis, settling synovitis, articular cartilage erosion, collagen fibril network break-down, and finally, slowing of osteophyte formation.(Johnson & Johnson 1993) However, following RCCL reconstruction, there is an increase in the global progression of the osteoarthritis disease process, proliferation of osteophytes and joint effusion as well as notable quadriceps atrophy at 7 and 13 months postoperatively.(Innes & Barr 1998; Innes et al 2004) Contralateral stifle joint osteoarthritis has also been detected following a unilateral cranial cruciate ligament rupture.(de Bruin et al 2007) DeCamp et al 1996 described gait alteration in dogs RCCL dogs. The stifle joint angle was more flexed throughout stance and early swing phase of stride and failed to extend in late stance. In contrast, the hip and tarsus were more extended during stance phase, and there was an overall loss of propulsion. The authors of this study noted that meniscal injury occurred in several of the study dogs by 3-months and commented that fibrosis of the joint is insufficient in 6 months to result in joint stability and significant improvement in gait.

The Cruciate Deficient Human Knee

A scant amount of literature has been published specifically dedicated to conservative rehabilitation of canine cruciate-deficiency.(Vasseur 1979) While some studies have used cruciate-deficient dogs as control animals, evidence-base rehabilitation programs are not generally part of standard management protocols for a comparable evaluation of this option. Human literature has attempted to make comparisons between surgical and conservative management of the cruciate-deficient knee and to study specific treatments and outcomes pertaining to the rehabilitation of the non-operative knee joint.

Ciccotti et al (1994) studied the EMG activity of anterior cruciate ligament deficient (ACL-D) knees as compared to normal and reconstructed knees at a walk. The same muscle activity was found in other movements as well. The findings are described in Table 1.

Table 1: EMG Activity in Muscles of ACL-D Knees as Compared to Normal and Reconstructed Knees in Humans

Muscle Activation	Implication
Increase in vastus lateralis activity at loading	Vastus lateralis resists internal rotation of the tibia
Increase in rectus femoris activity at pre-swing	This may indicate a decrease in knee flexion
Increase in biceps femoris activity at terminal swing	This may be to prevent anterior tibial translation with quadriceps contraction at loading
Increase in tibialis anterior activity at terminal stance	Tibialis anterior creates a dorsiflexion and inversion which also externally rotates the tibia (hence resisting internal rotation forces)

The authors concluded that rehabilitation does not restore normal EMG patterns, yet surgery does. They further postulated that there is likely a reduction in performance in ACL-D knees in more strenuous sports. These results also suggest that neuropathways other than those mediated by ACL mechanoreceptors exist to coordinate muscle activity. Other studies have shown a greater flexion angle in ACL-D knees during certain periods of stance.(Wexler 1998) Quadriceps weakness has been identified as common problem after ACL injury, and this weakness was persistent in patients with poor functioning knees.(Tagesson et al 2008) Prior to rehabilitation strengthening, these patients did not extend the injured knee to the same extent as the uninjured knee. While a certain amount of tibial translation is important to good functioning after ACL injury (Tagesson et al 2008), symptomatic ACL-D patients exhibited more anterior displacement than those who were asymptomatic during weight bearing.(Friden et al 1993) Yet, static tibial translation has not been found to correlate with functional outcome.(Tagesson et al 2008) Several studies have shown significant proprioceptive deficits to affect both the cruciate deficient or surgically reconstructed knee as well as the contralateral normal knee.(Roberts et al 1999; Friden et al 2001; Friden et al

1999; Zatterstrom et al 1994; Roberts et al 2000) There is a correlation between proprioceptive deficits and subjective knee function in patients with symptomatic ACL deficiency.(Roberts et al 1999, Friden et al 2001) There is also a relation between the patient's ability to detect passive motion and morphological lesions (chondral or meniscal lesions).(Friden et al 1999)

Rehabilitation of the Cruciate Deficient Human Knee

Some papers report conservative treatment of human anterior cruciate ligament deficiency to be unsuccessful or only successful in older or inactive patients.(Scavenius et al 1999; Strehl & Eggli 2007; Zysk & Refior 2000; Buss et al 1995) However, successful treatment of the non-surgical ACL deficient knee has been shown to be possible with specifically targeted rehabilitation programs.

Noyes et al (1983) proposed the rule of thirds for chronic ACL injuries treated with rehabilitation: 1/3 of patients can resume previous recreation activities without reconstruction; 1/3 manage without reconstruction by modifying or lowering their activity level; and 1/3 require reconstruction because of recurring giving way episodes even in activities of daily living. Thus creating 3 groups of patients: copers, compensators, and non-copers.(Noyes et al 1983) Comparisons of rehabilitated ACL-D and normal knees for function (using the single leg hop test) was found to result in 77% of the subjects having normal function at one year post-injury, 89% normal at 3-years, and 85% normal at 15 years of follow up.(Ageberg et al 2001; Ageberg et al 2007) Strength (isometric and concentric) as measured by the Biodex dynamometer was shown to be normal in 42 – 56% of the subjects at 1 year, 54 – 68% at 3 years and 69 – 82% at 15 years follow-up. (Ageberg et al 2001; Ageberg et al 2007) Activity levels change with rehabilitation management and surgical management of the ACL injured knee.(Kostogiannis et al 2007) Table 2 reflects the decline in activity levels regardless of the intervention using the Tegner activity level scoring system.

Table 2. Tegner activity level scoring following unilateral ACL injury (median)

Treatment	Pre-injury	1-Year Follow-up	3-Years Follow-up	15-Years Follow-up
Rehabilitation only	7	6	6	4
Reconstruction & Rehab	7	5	6	5

The same study also collected data on subjective knee function scoring / quality of life (QOL) scoring. Patients scored the highest 1 and 3 years following injury in the rehab-only group, with patient injured in contact sports scoring the lowest as compared to those injured in non-contact sports.(Kostogiannis et al 2007) Interestingly at the15-year follow-up, those patient with reconstruction surgery scored lower in the QOL scores than the non-reconstructed patients.(Kostogiannis et al 2007) This same cohort of patients was also evaluated for evidence of radiographic osteoarthritis at the 15-year mark following injury.(Neuman et al 2008) Sixteen percent of the rehabilitated patients developed radiographic osteoarthritis (OA). All of the patients with OA had undergone a meniscectomy. None of the non-meniscetomized patients developed OA. Sixty-eight percent of the patients reported to have an asymptomatic knee, while 23 % reported having reconstructive surgery at an average of 4-years after injury.(Neuman et al 2008) Myklebust et al (2003) found the 91% of competitive handball players treated without reconstruction could return to pre-injury activity level, whereas only 58% in the reconstructed group were able to do the same. A review of literature by Casteleyn (1999) concluded that while ACL reconstruction yielded the least amount of secondary meniscal surgery, osteoarthritic morbity was higher compared with a conservatively managed group. Sports participation tended to be higher in the reconstructed group as well.(Casteleyn 1999)

Conservative Rehabilitation of Cruciate-Deficiency

Successful management of the ACL-D knee in humans centres on some common goals: Early activity modification, neuromuscular knee rehabilitation, and strength training. (Ageberg et al 2007; Kostogiannis et al 2007; Neuman et al 2008; Tagesson et al 2008; Brotzman & Wilk 2007) It is appropriate to stage the rehabilitation goals and activities through rehabilitation. Time alone is not the signal for advancement from one programme to another, and attention should be paid to range of motion(ROM), strength, fluidity of performance of functional activities as well as functional testing.(Markey 1991) Using the goals for each phase of rehabilitation of an ACL-D human knee, treatment regimes can be proposed. Tables 3 – 6 illustrate the goals and this author's (LEH) suggestions for rehab of the canine patient in each phase.

Table 3. Goals and Treatment Suggestions for Phase 1 (Protection) of the Canine ACL-D Stifle

Phase 1: Protection (Weeks 1 – 4)	
Goal	**Suggestion**
Increase ROM	PROM flexion and extension; tummy rubs into extension; 'square' sitting practice.
Increase muscle function using movement synergies and utilizing motor learning transfer	Active sitting down to a stool (guiding rear legs for symmetry of movement); Toe pinches (alternating and simultaneous) in side lying; leash walking to toilet, progressing to 5 minutes and increasing time by 3 – 5 minutes per week (if no increase in joint inflammation); Weight shifting exercises; Balance board exercises (front legs on the board); Standing on soft surfaces and balance; 3-leg standing; step ups; Walking in circles or figure-of-8 patterns.
Increase proprioception	Joint compressions; Grades 1 – 2 joint mobilizations.
Decrease pain and effusion	Icing; PROM & AROM within pain tolerance; joint compressions; Grades 1 - 2 joint mobilizations; NMES; Modalities.

Table 4. Goals and Treatment Suggestions for Phase 2 (Early Strengthening) of the Canine ACL-D Stifle

Phase 2: Early Strength Training (Weeks 5 – 8)	
Full ROM	As above; may add toe-touch hanging, or extension on the stairs; may add sitting practice on a stool or platform.
Normal gait	Walking with a 'disturbance' on the unaffected foot; Obstacle walking or trotting; Steep up-hill walking or trotting;
Increase motor control (neuromuscular training) and strength	Underwater treadmill or swimming exercise; NMES or manual tapping on quadriceps or gluteals with 3-leg standing; NMES or manual facilitation on/of hamstrings with sitting practice; Side stepping or back stepping over a pole; Stepping up backwards; Walking backwards; Any of the above land exercises on a soft surface; Hill walking; Stair walking.
Load: 50 – 60% of uninjured limb	Increase time and duration of exercises above.

Table 5. Goals and Treatment Suggestions for Phase 3 (Intense Strengthening) of the Canine ACL-D Stifle	
Phase 3: Intense Strength Training (Weeks 9 – 12)	
Increased strength, and motor control (neuromuscular training)	Continue most challenging exercises from above; Walking with a weight on the affected leg (open kinetic chain training); Trotting up-/down-hills; Walking on uneven surfaces; Recall running between two people.
Increase Load: 70 – 80% of uninjured limb (increasing by 10% nearer end of stage)	Increase time and duration of exercises above; Perform exercises above with a weight pack.

Table 6. Goals and Treatment Suggestions for Phase 4 (Intensive strength training and return to sports) of the Canine ACL-D Stifle	
Phase 4: Intensive Strength Training and Return to Sports (13 – 16 weeks)	
Increased strength	Continue most challenging exercises from above; Destination jumping exercises from a stand (plyometrics).
Increased coordination	Agility-type training.
Increased ability in sport-specific activities	Short distance ball retrieves; 1 or 2 agility-type pieces of equipment; Avoid play with other dogs until closer to 6 months or longer and start with only short intervals.
Load 80% of uninjured leg (increasing by 10% nearer end of stage)	Increase time and duration of exercises above; Perform exercises above with a weight pack.

While natural healing of a meniscal tear has been reportedly possible (Ihara et al 1994), a meniscal injury may inhibit success of this regimen. Preventing osteoarthritis should be an important goal for all animals that have suffered a joint trauma. Human studies have found a correlation with glucosamine use and a reduction in joint space narrowing and erosive effects of OA over a period of three years (Bruyere et al 2003; Verbruggen et al 2002). Canine studies have found that the use of a glucosamine / chondroitin sulfate mixture can enhance synthesis and turn-over of the matrix of proteoglycans and collagen and hence can have a protective effect against synovitis and associated bone remodelling. (Johnson et al 2001; Canapp et al 1999) Cetylated fatty acids have also been shown in both human and animal studies to modulate the immune response and inflammatory process of osteoarthritis and in-turn improve ROM and overall function (Hesslink et al 2002; Curtis et al 2002; Richardson et al 1997). Advisement on nutritional supplementation should be considered just as important as physical management of the condition. Additionally excessive weight can impact the stresses on articular cartilage. A human study found that each pound of weight lost will result in a 4-fold reduction in the load exerted on the knee per step during daily activities (Messier et al 2005). A canine study found that dogs with hip OA that were fed 60% of their current calorie intake lost 11 – 18% of their body weight and experienced a significant decrease in hind limb lameness (Impellizeri et al 2000). Weight management should be deemed an integral part of rehabilitation of the cruciate-deficient dog.

Conclusion

Good functional recovery following a cruciate ligament injury is possible with conservative management. Older animals and those not engaged in high energy sporting activities might have an acceptable outcome with conservative care. Additionally, animals who are not surgical candidates for whatever reason may benefit from this evidence-based proposal for the conservative management of cruciate deficiency in dogs.

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