Therapeutic ultrasound as an aid in tibial fracture management in a dog

Therapeutisch ultrageluid als ondersteuning bij de behandeling van een tibiafractuur bij een hond

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ABSTRACT

A six-year-old, male, neutered Bernese mountain dog was presented with acute left hind limb lameness. Based on the symptoms, orthopedic examination and radiographic evaluation, a cranial cruciate ligament rupture was diagnosed. Surgical treatment with TTA Rapid was performed with good result. At two weeks postoperatively, the dog developed a fracture of the proximal tibia, due to excessive activity. Conservative treatment consisting of a splint and rest was advised. Physiotherapeutic ultrasonography and exercises were started to stimulate bone healing. After eight sessions, the dog was clinically much better, and radiographs showed a good evolution with a clear callus. Follow-up controls confirmed the progressive evolution.

SAMENVATTING

Een zes jaar oude, mannelijke, gecastreerde Berner sennenhond werd aangeboden met de klacht van acuut manken ter hoogte van de linkerachterpoot. Op basis van de symptomen, het orthopedisch onderzoek en radiografieën werd een voorstekruisbandruptuur vastgesteld. Er werd een TTA-rapid-ingreep uitgevoerd, met goed resultaat. Twee weken postoperatief trad een fractuur van de proximale tibia op door overdreven activiteit van de hond. Conservatieve therapie bestaande uit een spalk en hokrust werd geadviseerd. Omdat dit geen beterschap bracht, werd fysiotherapie met ultrageluid en oefeningen gestart om de botheling te stimuleren. Na acht sessies was de hond klinisch beter en ook de radiografieën toonden een goede evolutie met duidelijke callus. Follow-up controles bevestigden de gunstige evolutie.

INTRODUCTION

Rupture of the cranial cruciate ligament is one of the most common causes of hind limb lameness in dogs (Canapp, 2007; Comerford et al., 2011). During the last thirthy years, the prevalence has more than doubled (Griffon et al., 2010). In humans, the most common cause is trauma, but in dogs, it occurs mostly due to degeneration of the cranial cruciate ligament (Canapp, 2007; Ichinohe et al., 2015). The exact etiopathogenesis is yet unknown (Comerford et al., 2011). In about 40% of all cases, a rupture of the contralateral cranial cruciate ligament is also present (Fossum et al., 2013).

A frequently used treatment for this disease is an osteotomy technique, as there are: tibial plateau leveling osteotomy (TPLO), tibial tuberosity advancement (TTA) (Boudrieau, 2009; Fossum et al., 2013) and TTA Rapid (Samoy et al., 2015).

Complications of these techniques occur in 20 to 59% of cases (Boudrieau, 2009; Griffon et al., 2010). Bone related problems (tibial tuberosity-, fibular- or tibial fracture) occur in 4.9 to 7.1% of all cases (Boudrieau, 2009). Less complications occur if the number of technical problems decreases, for example with a more experienced surgeon (Boudrieau, 2009).

Bone healing can be supported by using ultrasound (Mosselmans et al., 2013). Initially, ultrasound was used to obtain a thermal effect on tissue (Millis and Levine, 2014), and was believed to have a negative effect on fracture healing (Watson, 2008; Millis and Levine, 2014). High doses were thought to delay

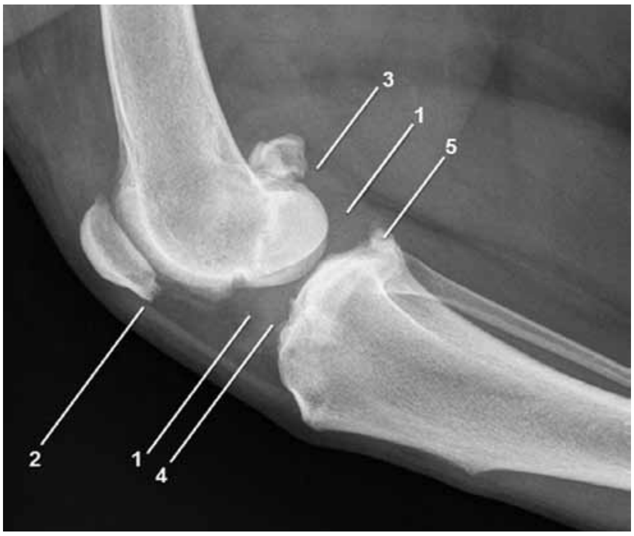

Figure 1. 1. Lateral view of the left stifle with swelling of the stifle joint cranially and caudally, 2. osteophytes at the distal patella, 3. the fabellae, 4. the tibial plateau, 5. lowering of the popliteus bone. A cranial displacement of the tibia cannot be noticed. (Photo: referring veterinarian).

Figure 2. Lateral view of the right stifle showing no abnormalities. (Photo: referring veterinarian).

callus formation and postpone its calcification. Demineralization, subperiostal damage or pathological fractures were considered as consequences of the use of ultrasound. However, later on, it has been demonstrated that ultrasound can stimulate physiological processes without thermal effect, for example bone healing (Millis and Levine, 2014).

The effect of ultrasound is dose-dependent (Watson, 2008). Pulsed ultrasound with low intensity (LIPUS) is an example of mechanical energy going through tissues as acoustic pressure waves (Claes and Willie, 2007). Depending on the density of the tissue, the ultrasound wave is absorbed and depending on the tissue absorption capacity, an effect occurs. The higher the amount of proteins and the lower the amount of water in the tissue, the higher the absorption of the ultrasound wave. Therefore, tendons, ligaments, fascia, joint capsules and scar tissue have the best absorption capacity. Bone also contains a lot of proteins and a small amount of water, but a large part of the waves is reflected at the bone surface (Watson, 2008). Thus, ultrasound is not capable of stimulating intact bone or a callus in the remodeling phase. It does stimulate the inflammation phase and the phase during which the softer callus is formed, as well as the formation of periosteal bone (Claes and Willie, 2007) by increasing osteoblast marker expression at both low (1,5 MHz) and high (3 MHz) frequencies (Monden et al., 2015). Hence, LIPUS ensures formation of a bigger callus and a faster return to the original bone strength. In addition, it influences all types of cells that play an important role in bone healing, such as osteoblasts, osteoclasts, chondrocytes and mesenchymal stem cells. Moreover, LIPUS influences the permeability of the cellular membrane and causes a higher cellular activity (Claes and Willie, 2007).

CASE REPORT

A six-year-old, male, neutered Bernese mountain dog was presented with acute lameness on the left hind limb. Trauma was unknown.

Physical examination revealed no abnormalities. On orthopedic examination, the dog was severely lame on the left hind limb (8/10). Palpation and manipulation revealed a severe swelling of the left stifle joint. The cranial drawer sign and tibial compression test were clearly positive and a mild click was noticed.

Radiographs of the left stifle showed joint effusion, osteophytes at the distal patella, the fabellae and the tibial plateau and lowering of the popliteus bone (Figure 1). Cranial displacement of the tibia could not be detected. The right stifle showed no abnormalities on orthopedic and radiographic examination (Figure 2).

Bilateral hip dysplasia was also diagnosed on radiography. Degenerative changes in the right hip were worse than in the left hip. Since the dog never had any related complaints, the degeneration was considered to be subclinical hip dysplasia (Figure 3).

Based on these findings, the dog was diagnosed with an acute cranial cruciate ligament rupture on the left stifle and subclinical bilateral hip dysplasia.

Initially, a conservative treatment with non-steroidal, anti-inflammatory drugs (NSAIDs) Cimicoxib (Vétoquinol, France) 2 mg/kg BID and Hill's™ j/d (Hill's Pet Products, USA) was started. Because of the unsatisfying results one week after conservative treatment, surgical treatment was advised. A tuberositas tibiae advancement (TTA) Rapid technique was

Figure 3. Cranio-caudal view of the hips and stifle joints. Clear hip dysplasia can be noticed, right is worse than left. (Photo: referring veterinarian).

Figure 4. Postoperative radiograph of the left stifle. 1. A fissure coming from the "maquet" hole is seen, 2. which required a screw for stability . (Photo: referring veterinarian).

performed (Samoy et al., 2015). During the operation, a complete rupture of the cranial cruciate ligament and an intact meniscus were seen. A 10.5/25 cage was used (width 10.5 mm, length 25 mm), followed by the application of hydroxyl-apatite bone paste. On postoperative radiographs, a fissure could be seen, originating from the "maquet" hole (Figure 4). Because of this complication, a 2.4-mm-position screw was placed to fix the bone. After surgery, restricted movement was advised, as well as cold-pack application for ten minutes four times a day for three days, the administration of NSAIDs for three weeks, antibiotics for five days and the supplement Kynosil® (Bioradix, Belgium), at 10 ml once a day.

One week later, the dog was examined by the referring veterinarian for a first follow-up visit. The first days after surgery, a positive evolution was noticed. Moderate lameness (5/10), moderate swelling of the joint and a mild periarticular crepitation in flexion were found. An almost normal stifle range of motion was present.

Five days later, the veterinarian was consulted again after the dog had escaped into the garden. He was acute lame on his left hind limb, sometimes without weight-bearing. Radiographs showed an avulsion fracture of the tibial tuberosity and a fissure of the proximal tibia (Figure 5).

Because of the minimal displacement and clinical presentation, the referring veterinarian opted for

Figure 5. Radiograph of the left stifle twelve days post surgery. 1. A distal fracture of the tibial tuberosity and 2. a fissure at the proximal tibia can be noticed. (Photo: referring veterinarian).

Figure 6. Radiograph of the left stifle, six weeks after ultrasound therapy. A clear callus is seen (arrows). (Photo: referring veterinarian).

Figure 7. Radiograph of the left stifle, three months after ultrasound therapy. A perfect callus with remodeling is visible (arrows). (Photo: referring veterinarian).

cage rest. One week later, a splint was placed, which slipped down several times. Because conservative treatment was not successful, the dog was referred to the Faculty of Veterinary Medicine, Ghent University, where it was advised to start physiotherapeutic ultrasonography to stimulate the bone healing process. At that time, the dog was still lame on the left hind limb with minimal support on that leg. Eight sessions with ultrasound (pulsed rate (frequency ¼), 3 MHz, 0,35 W/cm², 19 minutes) and physiotherapeutic exercises were planned (first week four sessions, second week two sessions and third week two session). A help'em up™ dog harness helped to perform the therapeutic exercises.

The exercises consisted of cavaletti walks (ten repetitions), circle walks with the affected limb towards the centre (five minutes) and balance board. From the third week on (seventh session), slope walking with the affected limb alternating downhill an uphill was started to improve respectively weight bearing and muscle buildup. After the second session, easy home exercises were started as well. They consisted of balance board exercises (five minutes a day) and circle walks (five minutes a day). In a later stage, slope walking was also introduced as a home exercise.

At session three, the dog showed improved weight-bearing on the left hind limb. After eight sessions, a good evolution could be seen, but continuation of the same home exercises was recommended.

Six weeks later, moderate lameness (4/10) on the left hind limb was still visible, but was considered normal for this revalidation period. Palpation revealed moderate muscle atrophy and mild swelling of the stifle joint, with a normal range of motion. At the medial side, a hard swelling could be palpated. This callus tissue at the fracture site was clearly demonstrated on radiography (Figure 6). The continuation of the administration of the dietary supplement Kynosil® (Bioradix, Belgium) was advised at 10 ml once a day.

Three months post physiotherapy, a very mild lameness (2/10) on the left hind limb was noted, but not visible to the owners. Radiographs showed a perfect callus with remodeling (Figure 7).

Six months after physiotherapy, the dog was doing very well and the owners didn't notice any lameness anymore. Supplementation of Kynosil® (Bioradix, Belgium) (10 ml once a day) and Hill's™ j/d (Hill's Pet Products, USA) were to be continued. There were no signs of problems at the contralateral stifle joint or the hips.

DISCUSSION

Diseases in the stifle joint are a common cause of hind limb lameness in dogs. Cranial cruciate ligament rupture is the primary problem in this joint, especially in medium and large breed dogs, whether or not combined with meniscal tears (Jerram and Walker, 2003; Canapp, 2007; Comerford et al., 2011).

The dog in this case had the typical characterization of breed, age and activity for cranial cruciate ligament injury. It was a middle-aged, large breed dog, which was quiet and without a lot of exercise (Jerram en Walker, 2003; Witsberger et al., 2008; Comerford et al., 2011). It was not clear if this lack of exercise played a role in the development of the cranial cruciate ligament rupture.

Trauma was not known when the acute lameness occurred. Degenerative rupture is the most common cause of cranial cruciate ligament rupture and has a multifactorial nature, which is not yet fully clarified (Comerford et al., 2011). A possible explanation could be that the subclinical hip dysplasia creates an chronic overload of the stifle, causing the cruciate ligament to tear. However, this is very difficult to prove and requires more research.

Radiographs were made to assess the degree of osteoarthritis (Jerram and Walker, 2003) and to perform preoperative measurements for TTA Rapid surgery (Fossum et al., 2013; Samoy et al., 2015). The regions where osteophytes were seen in the present case, for example the distal patella, the fabellae and the region of attachment of the cranial cruciate ligament on the tibia, are similar to the regions described by Jerram and Walker (2003). A cranial displacement of the tibia was not noticeable. Even when a complete cranial cruciate ligament rupture is present, the cranial displacement is not always clearly visible. Therefore, a tibial compression test should be performed during radiography (Jerram en Walker, 2003).

Conservative treatment was started, although in large breed dogs, the treatment is often not sufficient to resolve the pain and inflammation caused by the ruptured cruciate ligament (Fossum et al., 2013).

Because of the unsatisfying results of the conservative therapy in the present case, surgical treatment was performed using an earlier version of the TTA Rapid technique. In this version, a "maquet" hole is created at the bottom of the osteotomy, with the intension to cope with the advancement forces (Ramirez et al., 2015; Samoy et al., 2015; Marques and Ibanez, 2016). However, it has been demonstrated that it may function as a stress-riser, increasing the risk of tibial fracture. Nowadays, only osteotomy is performed without creating a "maquet" hole in the tibia (Y. Samoy, personal communication, 2015).

Complications that may occur with any surgical technique, are infection, insufficient stabilization, meniscal damage and osteoarthritis (Fossum et al., 2013). Meniscal damage can be prevented by performing a meniscal release during surgery (Samoy et al., 2015). More specific complications of osteotomy techniques are patellar desmopathy (Fossum et al., 2013; Samoy et al., 2015) or problems with the osteosynthetic material (Cosenza et al., 2015). An example of a complication occurring specifically with TTA Rapid is fracture of the tibia, whereby the risk is higher if the technique with the "maquet" hole is used (Samoy et al., 2015).

In this case, a fracture of the tibial crest and a fissure of the proximal tibia occurred, because of undesired excessive activity after surgery. Placing a splint was not sufficient, so other treatment methods had to be considered: surgery or alternative conservative treatment. Surgery was not the best option in this case, because the fracture was already two weeks old, it was only slightly displaced and the dog still showed some weight-bearing. Ultrasound therapy was started. It has been demonstrated that ultrasound can increase vascularization and the callus formation, and a quicker return to the previous strength of the bone can be achieved (Claes and Willie, 2007; Mosselmans et al., 2013). This is caused by an effect on the permeability of the cellular membrane and by a higher cellular activity. Moreover, there is an increase in protein production, fibroplasia and a better synthesis of collagen, which contributes to a quicker healing and recovery.

However, this case report has a few limitations. First of all, there was no control group or animal to compare the evolution of healing with. Whether ultrasound therapy was the only reason why the bone regeneration happened so fast and smoothly, is hard to tell, since all exercises involving weight-bearing have a positive effect on bone healing (Wolff, 1986). However, in both the human and the veterinary literature, it has been well-described that ultrasound therapy has a beneficial influence on bone regeneration; hence, it can be assumed that it had at least some effect (Claes and Willie, 2007; Mosselmans et al., 2013).

A second limitation is that there was no objective method available to determine the degree of lameness. Ideally, a pressure plate examination should be performed to evaluate improvement of the limb function. Since this technique was not available, lameness evaluation was mostly done by an experienced veterinarian.

The long-term evaluation at six months was made using an owner telephone questionnaire. Since the perception of lameness by the owner may differ from the objectively perceived degree of lameness, there may be some bias here. However, the dog had not clinically deteriorated since the last veterinary consultation; hence if lameness was present, it may only have been to a very mild degree.

CONCLUSION

Osteotomy techniques are gaining more and more popularity when it comes to cranial cruciate ligament treatment. Although osteotomy techniques have been shown superior to lateral surgery techniques (Murphy et al., 2014), they may result in severe postoperative complications, especially when postoperative restrictions are not followed. Surgical correction of these complications is often necessary, but in minimally displaced cases, physiotherapeutic ultrasound can be a valid alternative in the treatment protocol.

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