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Treatment of the cranial cruciate ligament deficient canine stifle-joint with tibial plateau levelling osteotomy and arthroscopic examination of the joint – a case report

Tibial plateau levelling osteotomy (TPLO) ja artroskopian käyttö koiran etumaisen ristisiteen vaurion leikkauksessa – tapausselostus

SUMMARY

Injury to the cranial cruciate ligament (CrCl) in the stifle joint is a very common problem in dogs. The osteoarthritic changes in the joint begin immediately due to the inflammation process caused by the CrCl trauma and excessive drawer motion within the joint. An early diagnosis is very important. Arthroscopy of the stifle joint is minimally invasive, gives a quick and exact diagnosis of trauma to the CrCl and is specially helpful in partially torn CrCl injuries without drawer motion. Traditionally used operation techniques are either extra- or intracapsular techniques, which intend to replace or mimic the injured CrCl and thereby to prevent the drawer motion passively. The results are inconsistent and do not provide normal joint function post-surgically. Tibial plateau levelling osteotomy (TPLO) was introduced by Slocum 1993 and is a technique based on a novel philosophy regarding joint stability. Decreasing the tibial plateau angle (TPA) neutralizes the cranial tibial thrust (CTT) and the stifle joint is stabilised actively by muscle action. The post-operative morbidity is clearly decreased with the combination of arthroscopy and TPLO.

YHTEENVETO

Polven etummaisen ristisiteen vaurio on hyvin yleinen koiran polvinivelessä esiintyvä vamma. Vaurioitunut ristiside ja vetolaatikkoliike aiheuttavat niveltulehduksen, joka nopeuttaa nivelrikkomuutoksien syntyä. Artroskopia mahdollistaa varhaisen ja tarkan diagnoosin asettamisen. Lisäksi toimenpiteen aiheuttama vaurio on vähäinen, mikä on ensiarvoisen tärkeää. Ristisideleikkauksen jälkeinen kipu vähenee ja toipilasaika lyhenee, kun artrotomian sijasta käytetään artroskopiaa. Perinteisesti käytetyissä leikkaustekniikoissa pyritään toiminnallisesti korvaamaan vaurioitunut ristiside ja näin ollen poistamaan ristisidevaurion aiheuttama vetolaatikkoliike. Leikkauksen jälkeiset tulokset vaihtelevat, ja nivelen biomekaniikka häiriintyy. Slocum esitteli vuonna 1993 tibial plateau levelling osteotomy (TPLO) -leikkausmenetelmän. Tässä perusajatus poikkeaa selvästi perinteisistä menetelmistä eli pienentämällä tibian tasanteen kulmaa pituusakselin poikittaisaskeliin nähden tasapainottuvat painorasituksessa polveen kohdistuvat voimat ja vetolaatikkoliike estyy. Tämä tapausselostus käsittelee koiran polven etummaisen ristisiteen vauriota, jossa nivelensisäinen tutkimus tehdään artroskopian avulla ja painorasituksessa esiintyvä vetolaatikkoliike poistetaan TPLO-menetelmän avulla.

INTRODUCTION

The most important stabilizing structure of the canine stifle joint is the cranial cruciate ligament (CrCl). Its primary function is to limit cranial tibial translation in respect to the femur, termed cranial drawer motion, and internal rotation. The introduction of the tibial plateau levelling osteotomy (TPLO), by Slocum 1993, for the treatment of the canine CrCl deficient stifle joint has brought new thinking in the management of CrCl injuries (Slocum 1993). Previous treatment methods intended to replace or mimic the function of the CrCl ligament and thereby to prevent drawer motion. These traditional methods function satisfactorily for CrCl rupture repair in small and middle sized dogs. However, in large breeds it is difficult to achieve a strong and functional stabilisation to balance the tibial thrust. Cranial tibial thrust (CTT) is a force created by compression of the femur and the tibia during weight-bearing and muscle contraction (Henderson and Milton 1978, Slocum 1984). The magnitude of CTT depends on the amount of compression and the slope of the tibial plateau with respect to the axis between the centre of motion of the stifle and the hock. Forces that oppose the CTT are both active (hamstring muscle contraction flexes) and passive

(CrCl, caudal horn of medial meniscus). If the CrCl is ruptured, each step with consecutive compression of the stifle leads to cranial translation of the tibia. The CTT can be controlled by decreasing the angle of the tibial plateau. Reducing this angle by crescent-shaped osteotomy and levelling of the tibial plateau balances the forces that act on the stifle during weight bearing and decreases the CTT. The goal is to reduce the tibial plateau angle (TPA) to 6–8 degrees (Slocum 1993).

For TPLO, precise pre-operative radiographs of both knees under anaesthesia are essential to define the TPA. A true lateral picture is made with the x-ray beam centred over the stifle joint and the tarsal joint included in the same exposure. The greater trochanter, head of the fibula, and the malleolus should be in contact with the surface of the x-ray table. The stifle and hock have to be positioned in 90 degrees flexion and the femoral condyles should be superimposed (Slocum 1993). The slope of the tibial plateau is identified by a line joining the cranial and caudal edges of the medial tibial plateau. The tibial functional axis is defined by joining the midpoint between the intercondylar tubercles and the centre of the talocrural joint. The tibial plateau angle is defined as the angle between the slope of the medial tibial plateau and perpendicular to the functional axis of the tibia (Slocum 1996).

Inspection of all structures of the joint cavity including the menisci is essential when a stifle is operated due to a CrCl injury. This is traditionally made by lateral or medial arthrotomy of the stifle joint. Inspection of intra-articular structures is limited by exposure, especially with partial CrCl injury where no drawer motion is present. Arthrotomy severely traumatises the surrounding soft tissues and joint capsule including sensitive neurofibres and leads to significant postoperative morbidity. Risk of bacterial contamination of the joint cavity is also present. Inspection of the stifle by arthroscopy decreases trauma and risk for bacterial contamination and improves the inspection of the joint cavity and the cleaning-up of remnant traumatised tissues. Combination of minimally invasive joint inspection and debridement by arthroscopy, followed by TPLO to stabilise the stifle joint, is a novel approach to CrCl injuries in heavy dogs with low postoperative morbidity, and leads to a good long term prognosis.

CASE REPORT

A seven year old, female, spayed, mixed breed (35 kg) dog was brought to the animal hospital because of a permanent weight bearing lameness on the right hind leg since one month. General physical examination was without pathological findings. During orthopaedic examination, a mild weight bearing lameness (grade II/V) on the right hind leg was found and the sit-test was positive. The sit-test is a good indicator of normal pain free range of motion in the stifle joint. In the test the dog sits several times and is observed if the leg is abducted while sitting. When the leg is abducted the sit-test is positive. On palpation, a slight atrophy of the thigh muscles, increased stifle joint effusion and swelling of the medial compartment around the collateral ligament were found. There was no obvious drawer motion and the tibial compression test was negative. On the basis of the history and the physical findings, we suspected a partial CrCl injury. The differential diagnosis included: soft tissue injuries (medial collateral ligament injury, isolated meniscus injury, joint capsule tear), bone trauma (avulsion fractures, etc.), inflammatory disease (degenerative joint diseases, infectious arthritis) and neoplasia.

After pre-medication with acepromazin and methadone, induction was performed with thiopental, and anaesthesia was maintained after intubation with isoflurane. Epidural anaesthesia was performed (lidocaine 2 % 12 mg, bupivacaine 0.75 % 0.62 mg, morphine 3.5 mg. The total volume was 7 ml).

Radiography was performed of both stifles according to the descriptions by Slocum mentioned earlier in this text.

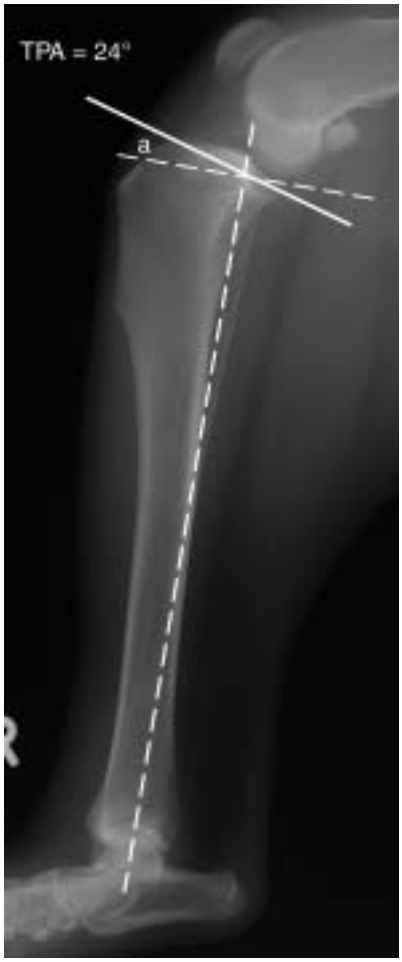


FIGURE 1

Pre-operative radiograph for estimating the TPA. The TPA (a) is the angle between the tibial plateau (full line) and a line perpendicular to the tibial functional axis (dotted line). The TPA is 24° in this case.

Routine preoperative preparation of the surgical field from proximal femur to mid-metatarsal bones was made. The dog was positioned in dorsal recumbency on a vacuum bag so that both legs could hang free from the end of the table. The table was tilted head-up, approximately 30 degrees. The vacuum bag supported the flexed knee laterally and medially, and allowed the leg to hang straight without deviation to the side (Beale et al. 2003).

Inspection of the joint was performed arthroscopically. Proper visualization requires careful attention to the placement of the arthroscope, the orientation of the light post and the position of the limb. Three portals are routinely made for stifle athroscopy. For the optical portal a stab incision with a no. 11 blade was made. The trochar sheath was introduced midway between patella and tuberositas tibiae lateral to the patellar ligament. Before the arthroscope was introduced a Kirschner pin (2.0 mm) was inserted into the trochar and passed through the medial capsule from inside the joint to the outside and a egress needle was inserted over the Kirschner pin into the medial parapatellar compartment as the outflow portal for the irrigation fluid. The arthroscope was then inserted into the joint through the trochar sheath. Systematic inspection of the proximal parapatellar, medial, lateral and cranial compartments was performed. The inflammatory process of the synovial membrane, presence and severity of osteophytes and quality of the femoral and patellar cartilage were estimated. The appearance of the cranial compartment was affected by the inflamed fat pad, which had partly to be removed with a motorized shaver and a 3.5 mm full radius resector blade introduced through a instrumental portal medial of the patellar ligament. The instrumental portal was made at the same proximodistal level and angle as the optical portal, the lines of insertion cross in the joint and is referred as triangulation. Triangulation is important for successful visualisation and manipulation of the instrument (Beale et al. 2003). A window was cut into the fat pad with the motorized shaver, which increased the view within the cranial compartment of the joint. Inspection of the cranial compartment begins with the intercondylar notch, the CaCl and the CrCl, the intermeniscal ligament, lateral and medial menisci. The caudo-lateral part of the CrCl was injured; the synovial membrane around the ligament was ruptured and both menisci were intact. The CrCl fibres were debrided with a punch forceps (2.5 mm).

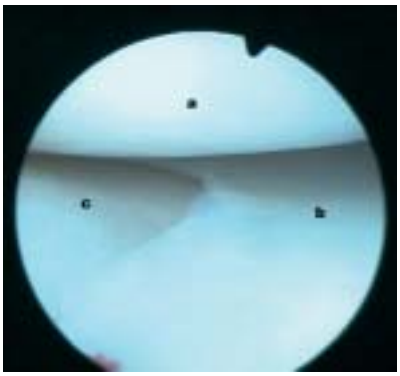
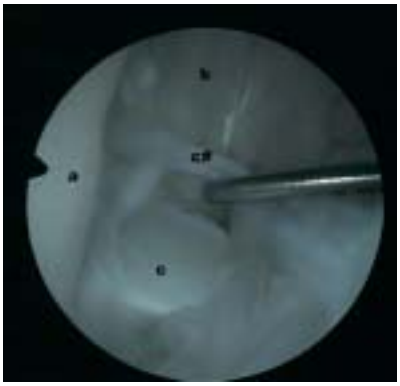


FIGURE 2

Arthroscopic picture of the intact medial compartment of the stifle showing the medial condyle (a), medial meniscus (b) and the tibial plateau (c).



After arthroscopic inspection of the stifle joint, the position of the leg for the TPLO procedure was changed without re-draping the dog. The body was tilted to the right so that the right leg could be positioned for a medial approach to the proximal tibia. A skin incision from the level of the medial condyle to the proximal third of the tibia was performed. Subcutaneous tissues and deep fascia along the cranial border of the insertion of sartorius muscle were incised (Slocum 1993). The distal end of the medial collateral ligament was identified. Circumferential preparation of soft tissues was made in the area of the osteotomy line. The deep crural fascia was incised and the popliteal muscle was carefully elevated along the caudal surface of tibia, avoiding injury to the popliteal artery, which runs inside the muscle. A small incision was made at the cranial edge of the tibia and the cranial tibial muscle was elevated from the lateral tibia. The dead space created between tibia and the soft tissues was filled with wet surgical sponges.

The joint space was identified by insertion of a sub-dermal needle at the level of the medial collateral ligament. A 3.2 mm Imex Ellis pin was drilled into the tibial plateau perpendicular to the tibial long axis about 5 mm distal to the joint space through the medial collateral ligament. The direction of drilling was assisted by a special tibial jig.

FIGURE 3

Arthroscopic picture of the partly injured CrCl showing the lateral condylus (a), the CaCl (b), the intact part of the CrCl (c) and the injured part of the CrCl (c#).

The jig functions first as a drilling guide to position the pins perpendicular to the tibial axis. When the jig is tightened to the pins, it functions as a reduction device (temporary external fixator) until the osteotomy is fixed by the plate.

A crescent-shaped osteotomy was made through the proximal tibia with a bi-radial saw blade (24 mm). The direction of the cut should be perpendicular to the long axis of the tibia with the radial centre at level of the proximal pin. The size of the saw blade is essential for placing the osteotomy line correctly. The magnitude of the tibial plateau rotation is calculated with a preoperative radiographic measurement of the tibial plateau slope angle. Once the magnitude of rotation is calculated, matching reference marks were made on either side of the osteotomy line (Slocum 1993). When the osteotomy was completed, the proximal tibial fragment was rotated around the proximal pin, which acts as a centre of rotation. The rotation was continued until the reference marks were aligned. A TPLO reduction pin (2 mm) was drilled in a cranio-caudal direction into the fragments for maintaining the position temporarily until the plate was fixed. A Slocum TPLO-plate was contoured to the bone surface and fixed with 6 cortical screws (3.5 mm). The plate is specially designed for this procedure; with three neutral holes in the distal part and two compression and one neutral hole in the proximal part. The plate was applied to compress the proximal portion of the tibia against the distal portion by means of radially aligned compression holes to provide rigid internal fixation (Slocum 1993). Different plates for the left and right leg and three different sizes are available (2.0, 2.7, 3.5). After the plate was in place, the pins, the jig and the sponges were removed; fascia, sub cutis and skin were closed routinely.

Post-operative x-rays were made

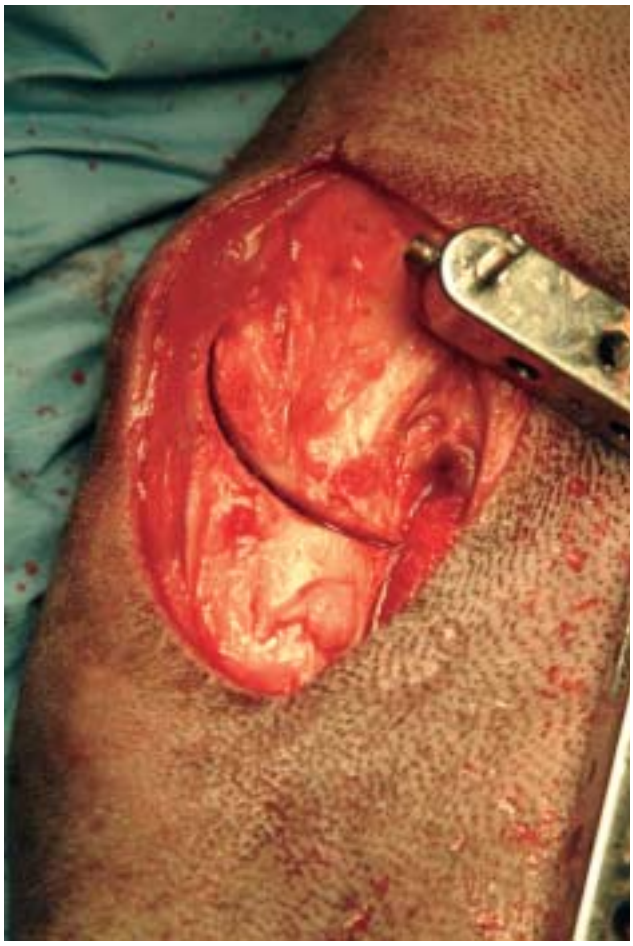


FIGURE 4

Intraoperative view of the medial tibia after crescent shaped osteotomy of proximal tibia fixed with the jig.

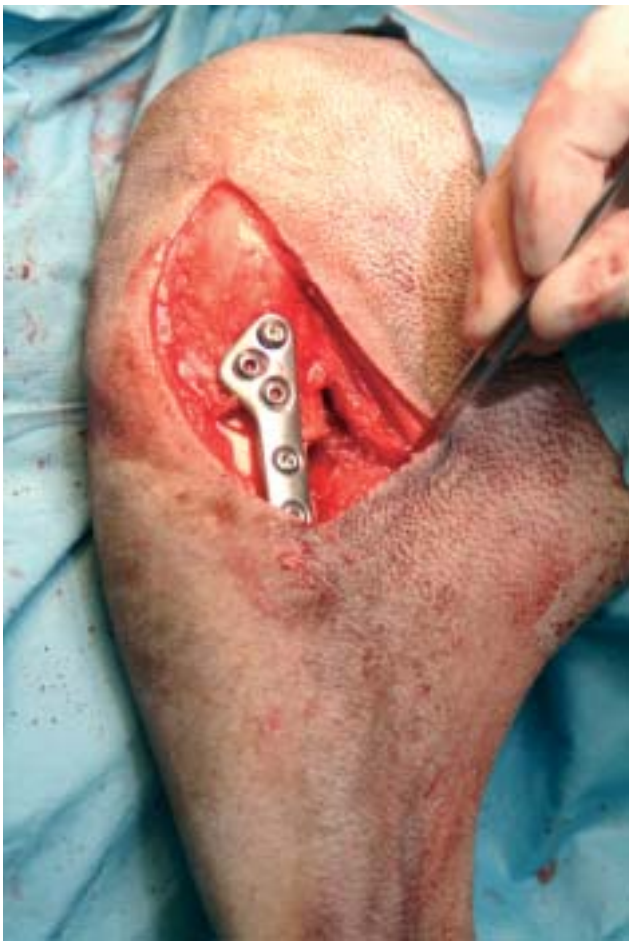


FIGURE 5

Intraoperative view of the medial tibia showing the tibial plateau rotated and fixed with a Slocum TPLO plate.

to evaluate the post operative TPA as well as plate and screw position. The TPA was 8° in this case. A soft cast (3M, Scotch semi-rigid cast) was applied to allow immediate weight bearing on the leg but, at the same, control flexion and extension of the stifle. It was accustomed and destabilised in stages, one layer per week, over three weeks time. The forces acting on the knee increased slowly, which reduced post operative pain, and improved the controlled use of the leg (controlled progressive joint mobilisation). The exercise was confined until the soft cast was removed after three weeks. After that, over five weeks, walking on the leash was slowly increased. Physiotherapy, to improve the range of motion in the stifle joint, was also started when the soft cast was removed. Eight weeks post-operative, the sit-test was negative; weight-bearing and walking were normal.

DISCUSSION

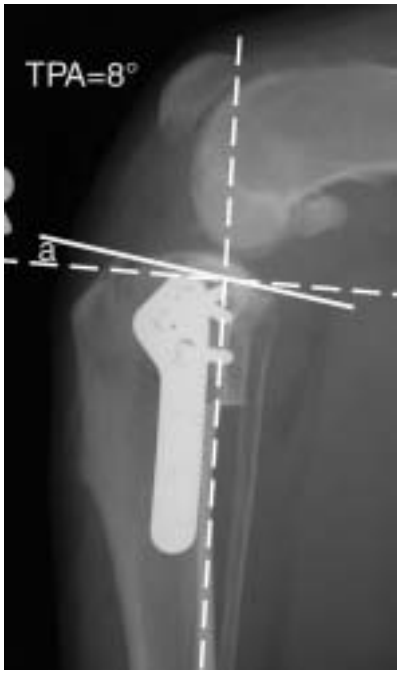


FIGURE 6

Post-operative radiograph showing the TPA of 8 degrees.

Injury to the CrCl is a common orthopaedic problem encountered in the canine stifle joint. The diagnosis of lameness caused by complete or partial tear of the CrCl is often delayed. Osteoarthritis advances rapidly within weeks in large-breed dogs with complete ruptures of the CrCl, but also in palpably stable stifles with partial rupture of the CrCl. This emphasizes the need for early diagnosis and treatment of the CrCl injury. As many veterinary surgeons are reluctant to perform exploratory arthrotomy in stifles without palpable instability, arthroscopy provides a minimally invasive technique with critical and precise inspection of all intra-articular structures. Because the structures are highly illuminated, greatly magnified and continuously flushed in an aqueous environment, viewing is greatly improved compared to traditional arthrotomy. This permits improved diagnostic capability for more accurate assessment of fibrillated cartilage, synovial inflammation, meniscal injuries and subtle partial tears of the CrCl (Beale et al. 2003). There is a strong association between CrCl and meniscal injuries in dogs. In a retrospective study, injuries were found in both the lateral and medial meniscus. The percentage of joints found with lateral meniscal injuries is much higher than previously reported, possibly because of use of arthroscopy (Ralphs and Whitney 2002). Treatment, including surgical management of the menisci, debridement of torn cruciate ligament fibres, partial synovectomy and surgical management of articular cartilage lesions, is more precise with much less post-operative morbidity associated with cutting the highly innervated joint capsule as performed with traditional arthrotomy (Beale et al. 2003).

Complications associated with arthroscopy are minimal and uncommon. Swelling due to subcutaneous fluid extravasation can be kept minimal by cautious introduction of the portals, but is usually reabsorbed rapidly within 24 hours, postoperatively. Attention has to be paid to avoid cartilage damage when introducing the trochar and instruments and when working in the joint. Intra-articular haemorrhage is usually controlled by temporarily increasing the ingress fluid or by intra-articular electrocautery (Beale et al. 2003).

Arthroscopy of the stifle joint can be used in conjunction with various intra- and extra-articular stabilisation techniques, thereby avoiding the necessity of arthrotomy and reducing post-operative morbidity.

Traditionally, extra- and intracapsular techniques are used to treat CrCl injuries in veterinary medicine. The presumption is that stabilizing the stifle passively against the cranial drawer sign restores normal function (DeAngelis and Lau 1970). The recent postoperative results with traditional techniques in veterinary medicine are still no different from what was written in the fifties, based on experience in human cruciate-surgery. This is to say that the surgical treatment of the CrCl is better than conservative treatment. It is, however, inconsistent and does not provide normal joint function post-surgically (De Palma 1954).

Extracapsular stabilisation is least invasive, but has several disadvantages. It is difficult to achieve a functional, strong and lasting fixation by inserting an implant with fixation points far away from the natural origin and insertion of the CrCl (Hoogland and Hillen 1984). The implant is passed around the sesamoid bone, which could cause increased tension and tissue necrosis. Common complications are implant failure and ultimate joint stabilization is probably due to accentuation of periarticular fibrosis (Brinker et al. 1990).

Fibular head transposition relies on the lateral collateral ligament as a restabilising structure (Smith and Torg 1985). Frequent complications encountered with this technique are iatrogenic fracture of the fibular head, accidental transection or avulsion of the lateral collateral ligament, iatrogenic injury to the peroneal nerve, inadequate stabilisation of the stifle joint with persistent drawer motion and pin or screw migration or failure. The biomechanics of the stifle joint is severely altered and may traumatize the menisci in extra-capsular stabilisation techniques. Internal rotation of the stifle is decreased, which increases the pressure on the menisci during stifle flexion (Arnoczky et al. 1977, Mullen 1989).

With intracapsular techniques, even though fixation points of the graft get close to the origin and insertion of the original CrCl, they are never anatomically correct. This contributes to the known complications with graft failure and graft survival (Hoogland and Hillen 1984). Either graft type, synthetic or autologous fascia lata, causes a inflammatory joint reaction, which can weaken this structure. The fascia lata graft should be protected from excessive stress during its revascularisation; and still, when vascularised, the strength is only 30 % of an intact CrCl (Denny and Barr 1987).

Osteoarthritis in the stifle joint is progressive with all passive stabilisation techniques, and the normal range of motion is often decreased, although the clinical outcome may appear successful. Postoperatively, the sit test remains positive almost consistently (Vasseur and Berry 1992).

TPLO is a technique which relies on a novel philosophy regarding joint stability. Decreasing the tibial plateau angle by levelling the tibial plateau caudally, the cranial tibial thrust is neutralized or counter led into caudal tibial thrust. With this, the stifle joint is stabilized actively by muscle action and the main passive restraint of the stifle joint is the CaCl. The benefit of this technique increases in large breed dogs because of the elimination of the risk of a graft failure or inflammatory reaction in the joint. It also is the ideal method for the treatment of partial tears of CrCl by altering the mechanics of the stifle joint, improving active stability of the joint and decreasing the load on the remnants of the ligament during weight bearing (Slocum 1993).

Due to changes in the slope of the tibial plateau angle, there is increased stress to the caudal parts of the menisci and the CaCl (Warzee et al. 2001). A meniscal release was proposed by Slocum in order to relief the increased pressure to the caudal horn of the medial meniscus (Pacchiana et al.2003). In partially torn CrCl, joint stability is preserved; so, it is unnecessary to compromise the function of the meniscus by releasing it (Whitney et al. 2002). In humans, total meniscectomy leads to significant long-term osteoarthritis; the same is likely true in the canine stifle with partial or complete removal of the meniscus (Beale et al. 2003).

TPLO is associated with a greater number of complications than other CrCl stabilization methods. However, the incidence of major complications is similar between TPLO and other stabilization methods (Pacchiana et al. 2003). With increased tension on the caudal cruciate ligament, a caudal cruciate ligament rupture is theoretically possible (Warzee et al. 2001). Intraoperative complications that may be encountered are excessive haemorrhage by accidental laceration of the popliteal artery, intraarticular screw impingement or tibial tuberosity fracture. Postoperative complications that can be seen are: haematoma or seroma formations, patellar tendon swelling, fracture of the tibial tuberosity, subsequent meniscal injury and implant loosening or failure (Pacchiana et al. 2003).

The demand of the procedure regarding support staff and instrumentation is greater than in traditional techniques. An oscillating saw, the patented armamentarium and orthopaedic instrumentation are needed. Implants increase the costs and make the TPLO procedure about 30–40 % more expensive than the traditional techniques. When combined with arthroscopy, the instrumentation demands increase even more. On the other hand, the operation wound is only about 10 cm long and the invasiveness is clearly decreased and limited to the area of osteotomy. The highly innervated joint capsule and adjacent structures stay intact; minimal scarring with less postoperative inflammation and pain can be expected. In our experience, weight-bearing on the operated leg is observed the first day postoperative and, therefore, the shift of the weight load to the opposite leg is moderate and the risk of injury to the contra lateral leg by overuse is decreased.

There are only a few studies about long-term follow up and outcome of the TPLO procedure but the results are encouraging (Schwarz 1999, Palmer 2000, Rayward 2004). Our own experience is similar to those reports, and TPLO has become the preferred surgical procedure for CrCl injury in heavy large breed dogs and very active medium breed dogs. Our experience with TPLO includes about 150 cases, and combined with arthroscopic joint inspection, about 100 consecutive cases. Special training is needed and the learning curve for the surgeon is long, about 20–30 operations are needed to learn the routines. Mean duration of the surgery, in the hands of an experienced surgeon, is 30–60 minutes for the arthros-

copy and 60 minutes for the TPLO. Evaluation of intermediate and long term results is ongoing and will be presented soon. The prognosis seems to be excellent and full recovery to previous activities can be expected even for working and athletic dogs. Full recovery to a normal sitting position, negative sit-test, with full flexion of the stifle is proof for the best possible biomechanical recovery, and this is achieved in most cases.

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