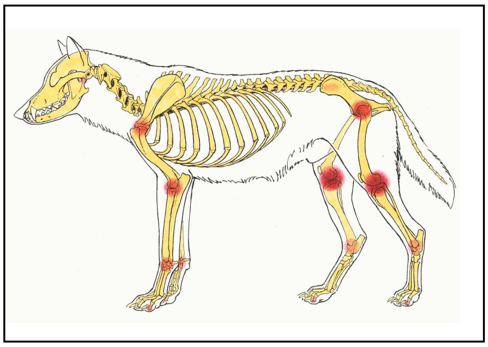
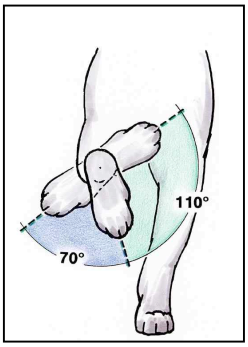
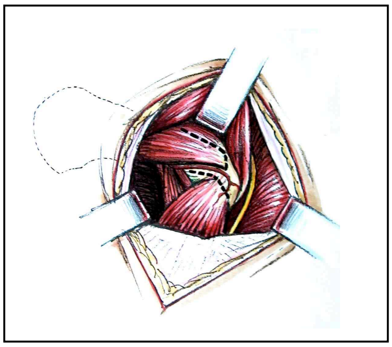
Brisbane, 2008

# Introduction to small animal surgery

# Orthopedic examination, approaches, joint surgery





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## Program

| Time | Topic | Goals | Mode of interaction | Speaker<br>Faculty |
|---|---|---|---|---|
| 0830 | Welcome | | | |
| 0845 | Orthopedic examination | Understand steps of orthopaedic examination<br>Be able to go to self-training | DVD | Koch |
| 0930 | Orthopedic examination | Be able to do a correct examination<br>Have guidelines for correct diagnostics | Practical exercise; group work (2-3 part.) | Koch<br>1-2 staff from BVSC |
| 1030 | Break | | | |
| 1045 | Case study 1 | Retrieve important tricks for diagnosing orthopedic problems | | Koch |
| 1130 | Patellar luxation | Know, how to diagnose PL, list the indications for surgery, know how to do tibia transposition and sulcoplasty | Theory | Koch |
| 1215 | Lunch | | | BVSC |
| 1315 | Patellar luxation | Perform the surgery safely | Wetlab | 1-2 staff from BVSC |
| 1400 | Cranial cruciate ligament rupture (extracapsular repair) | Understand pathogenesis of the disease, find out the correct therapy, know about corrective osteotomies | Theory | Koch |
| 1445 | Break | | | |
| 1500 | Flo's procedure | Perform the surgery safely | Wetlab | 1-2 staff from BVSC |
| 1600 | Hip luxation | Know how to reduce the hip, know how to decide which technique is approproiate | Theory | Koch |
| 1630 | Hip luxation, Slocum's technique | Be able to approach the hip through a lateral approach; perform a Slocum sling correctly | Wetlab | 1-2 staff from BVSC |
| 1730 | Case study 2 | Retrieve important tricks for diagnosing orthopedic problems | | Koch |
| 1800 | End of the day | | | |

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# 1 General orthopedics

## 1.1 Examination of the orthopedic patient

| Order of examination | | Manipulations, test | Some diagnostical advices |
|---|---|---|---|
| **Anamnesis** | Signalment | - breed predilection | Dachshound: disk herniation; Bernese mountain dogs, German shepherd dogs, Rottweilers, Retrievers: elbow dysplasia; Dobermann pinschers: Wobbler's syndrome |
| | | - size | Small dogs: patellar luxation to medial, Legg Perthes; large dogs: patellar luxation to lateral, elbow dysplasia, hip dysplasia, cruciate ligament rupture |
| | | - age | young dogs: OCD, panosteitis; old dogs: arthrosis, tumors, cruciate ligament rupture |
| | Anamnesis | - First open questions („what is the problem“), let the owner talk, then:<br>- closed questions:<br>„since when….“<br>„how happened, accident ?...“ | 50 % of all lamenesses come out of the stifle joint |
| | | „when do you see the lameness…” | lameness at the beginning = degenerative; at the end: inflammatory |
| | | “lameness increasing?...”<br>“premedications, success…”<br>“use of the pet….”<br>Other questions | Toes on the ground, difficulties with stairs and jumping into the car with hip dysplasia and coxarthrosis |
| **Gait** | Getting up | Look at the pet after long phases of inactivity:<br>- getting up<br>- first 2-3 steps | Many lamenesses are very discreet, they shall not be missed; these speak for degenerative processes |
| | Standing | - position of the leg (rotation, position to body) | |
| | | - stretching of the head | Relief of the hindlimbs |
| | | - bending of the back, hindlegs under body | Relief of the frontlimbs |
| | | - axial deviations (varus, valgus) | Growth disturbances (radius curvus, trauma to physis) |
| | Locomotion | - First 10 – 15 meters in normal steps, then in trot | Lameness during weight bearing: distal problem |
| | | - find out the affected side (without weight bearing or shorter stride, head on healthy side) | Lameness in hanging phase: proximal problem<br>Intermittent lameness hindlimb: probably patellar luxation (PL) |
| | | - eventually make circles, go on stairs, jumps<br>- specify the degress of the lameness (1-4) | |

| | | | |
|---|---|---|---|
| **Examination in upright position** | | **General principles:**<br>**- examination from distal to proximal**<br>**- affected extremity as the latest**<br>**- compare with contralateral limb**<br>**- repeat the tests**<br>**- painful tests at the end** | |
| | Short neuro-check | - Check proprioception<br>- turn head into all directions<br>- palpate the vertebral column<br>- perform other neurological examinations if necessary | It is important to exclude an existing neurological problem, e,g, disk herniation |
| | Hindlimb | - pull test on tarsi | Determination of affected side |
| | | - pain mass test on toes | Fractures, tumors, sesamoid disease |
| | | - check joint effusions and masses on tarsus | OCD, fracture |
| | | - palpate long bones (tibia, fibula) | Panosteitis, fractures, tumors |
| | | - palpate patella and check for painful manipulations | Patellar luxation (PL) |
| | | - check for stifle joint effusion, masses and instabilities | CrCL rupture, PL, OCD etc |
| | | - palpate the long bone (femur) | Panosteitis, fractures, tumors |
| | | - asses the muscle mass on the thigh | General indication for affected side |
| | | - extend, abduct and flex the hip joint | Hip dysplasia, Arthrosis, myopathies |
| | | - extend and rotate inwards the hip joint | Iliopsoas strain |
| | | - compare distance of the sciatic tuber and the great trochanter | Hip luxation |
| | | - make hyperextensions of the lumbosacral joint | Lumbosacral problems, spondylosis, fractures |
| | Frontlimb | - push test carpus | Determination of affected side |
| | | - carpal joint: effusions, masses | Fractures, tumors, sesamoid disease<br>Hyper extension trauma, M. abd. Poll. Long. |
| | | - palpate long bones | Panosteitis, fractures, tumors |
| | | - compare elbow joints | Elbow dysplasia, luxations, arthrosis |
| | | - inward and outward rotation fro elbow joints in 90° | Elbow dysplasia, elbow luxation |
| | | - shoulder joint: abduction of maximally 20° whilst extensions of elbow and shoulder joint | Medial luxation |
| | | - biceps test: deep palpation of medial shoulder joint or insertion on radius | Tenovaginitis of the biceps tendon |
| | | - check muscle mass on shoulder joint | General indication for affected side |

| | | | |
|---|---|---|---|
| **Examination in lateral recumbency** | Hindlimb | Phalangeal joints: | |
| | | - Flexion and extension of all joints | Fractures |
| | | - Overextension of metatatarso phalangeal joints | Sesamoid disease, polyarthritis, leishmaniosis |
| | | Metatarsus: | |
| | | - Palpation of the bones | Fractures |
| | | Tarsus (with stifle joint flexed): | |
| | | - 165° extension is normal, flexion until metatarsals are parallel to femur | |
| | | - check short collaterals in flexion | Rupture of the collateral ligaments or malleolar fracture |
| | | - check long collateral in extension | Rupture of the collateral ligaments or malleolar fracture |
| | | - all intertarsal joints must be stable | Trauma, fractures, luxations |
| | | - check medial tarsus for pain in flexion | OCD of the medial talus |
| | | Tibia / Fibula: | |
| | | - Palpation | Panosteitis, fractures, tumors |
| | | Stifle joint: | |
| | | - Flexion, extension, look for pain and crepitation | Osteoarthritis, meniscal problem, Salter Harris fractures |
| | | - drawer sign and positive tibia compression test with slightly flexed stifle joint | Cranial cruciate ligament rupture |
| | | - deep medial palpation | Meniscal problems |
| | | - Rotation (normally 5-6° inward and outward rotation) | Increased inward rotation with partial CrCL rupture |
| | | - check medial and lateral collaterals | |
| | | - patella: extension of stifle and hip and inward rotation for medial PL; flexion of stifle and hip joint and outward rotation for lateral PL | Patellar luxation |
| | | Femur: | |
| | | - deep palpation | Panosteitis, fractures, tumors |
| | | Hip joint: | |
| | | - rotation of the hip joint (crepitation, pain, extreme movements) | Osteoarthritis, Legg Perthes, fractures, luxations, tumors, hip dysplasia |
| | | - full extension and production of pain | Coxarthrosis |
| | | - extension and inward rotation is painful | Myositis M. ilipsoas |
| | | - deep palpation of M. pectineus | Hip dysplasia, coxarthrosis |
| | | - Ortolani test (adduction; subluxation, abduction) | Hip dysplasia |
| | | - Bardens test (subluxation of femur in youg dogs) | Hip dysplasia |
| | | - Check position of greater trochanter and tuber ischiadicum | Hip luxationm, femur head fracture, acetabulum fracture |

| | | |
|---|---|---|
| Front limb | Phalangeal joints: | |
| | - Flexion and extension of all joints | Fractures |
| | - Overextension of metatacarpo phalangeal joints | Sesamoid disease, polyarthritis, leishmaniosis |
| | Carpus: | |
| | - normal is 30° flexion, 210° extension; in flexion 5° valgus , 15° varus | Hyperextension trauma |
| | - drawer sign (only in cats) | Medial collateral ligament rupture |
| | - Finkelstein test | M. abductor pollicis longus tenovaginitis |
| | Radius / Ulna: | |
| | - Palpation | Fractures, panosteitis, tumors, HOD (distal) |
| | Ellbow | |
| | - Flexion, extension: production of crepitation and pain<br>- Extension: Production of Pain | Osteoarthritis, elbow dysplasia, fractures (Salter-Harris, lateral condylus), FCP, OCD, UAP (especially when lateral effusion and German Shepherd Dog) |
| | Humerus: | |
| | - Palpation: | Fractures, panosteitis, tumors |
| | Shoulder joint: | |
| | - Flexion, extension, abduction | Osteoarthritis, OCD, avulsion of the biceps tendon, |
| | - Extension: production of pain | tenovaginits of the biceps tendon, luxation |
| | - Deep palpation of the biceps tendon | tenovaginits of the biceps tendon |
| | - Check position of greater tuberculum relative to acromion | Luxation, subluxation of the shoulder joint |

**Further diagnostic tools**

- Neurologic examinbation
- Radiography
- Ultrasound (Muscles, tendons)
- Computed tomography
- magnetic resonance imaging
- arthroscopy
- biopsy

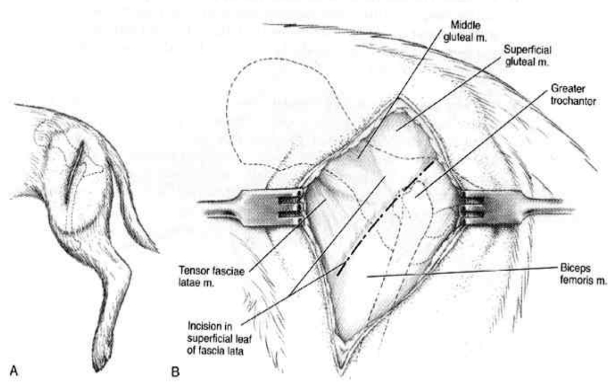
**References**

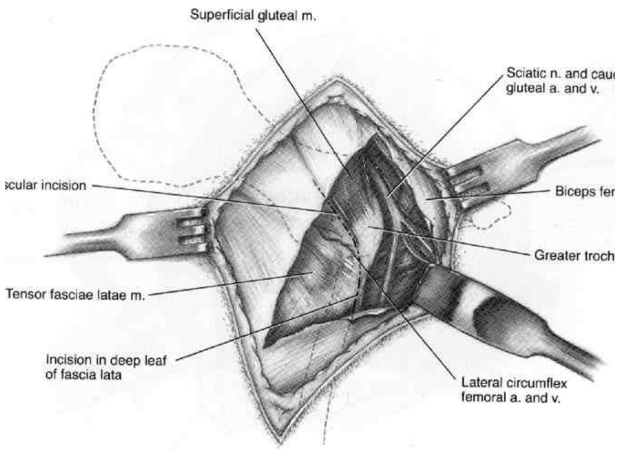
Hazewinkel HAW, Meutstege FJ (1990): Locomotieaparaat. In: Rijnberk A., de Vries H. Anamnese en lichamelijk onderzoek bij gezelschapsdieren. Bohn, Stafleu, Van Loghum, 175 – 200.
Sumner-Smith G. (1993): Gait analysis and orthopedic examination. In: Slatter D (ed). Textbook of small animal surgery. Saunders Company. Philadelphia, 1577 – 1586
Krämer M (1998): Der klinisch-orthopädische Untersuchungsgang der Gliedmasse, demonstriert am gesunden Hund. Ein Videofilm. Dissertation Universität Zürich.

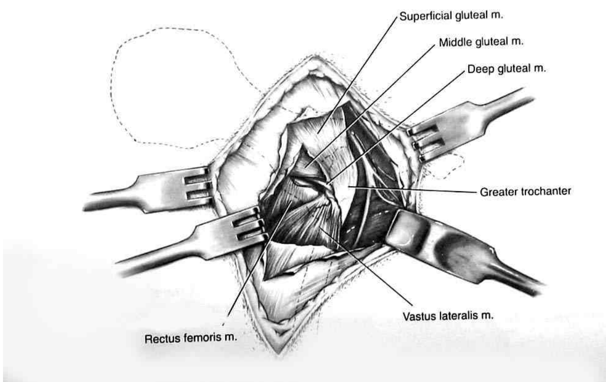
## 1.3 Approaches to the large joints

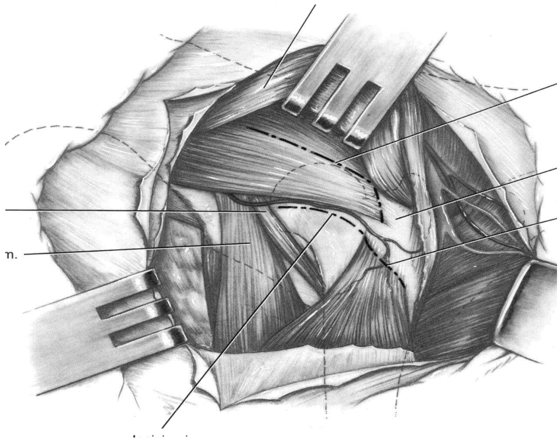
### 1.3.1 Approaches to the hip joint

The **craniolateral approach** or the modified craniolateral approach is the most commonly used approach to the hip joint. It allows exposure of the caudal aspect of the iliac body, cranial third of the acetabulum, and cranial and dorsal aspects of the femoral head and neck. Retraction of the biceps muscle caudally, the tensor fasciae latae cranially and the superficial gluteal muscle caudally exposes the hip joint. It is bordered dorsally by the middle and deep gluteal muscle, cranially by the rectus femoris muscles and laterally by the vastus lateralis muscle. Retraction of these muscle permits exposure of the cranial joint capsule. Exposure is enhanced by performing a tenotomy of the insertion of the deep gluteal muscle at the greater trochanter.



The **dorsal approach** is combined with a trochanteric osteotomy. The superficial gluteal muscle is isolated, incised at its insertion on the third trochanter and reflected dorsally. The osteotomy is started at the level of the third trochanter and is extended medially to the junction of the greater trochanter and the femoral neck, which is identified with the help of two mosquitos. The middle and deep gluteal muscle are reflected dorsally with the greater trochanter requiring separation of the deep gluteal from the dorsal joint capsule. After repair of the fracture, the greater trochanter is reattached to the proximal femur with the tension band technique. Chevron osteotomies require only minimal fixation, i.e. with screws.

Trochanteric osteotomy

A **dorsal approach** by splitting the gluteal muscles directly over the fracture is an alternative to the osteotomy. This approach is recommended for minimal or non dislocated fractures of the acetabulum. The gluteal muscles are splitted and retracted to allow visualisation of the dorsal aspect of the acetabulum.

The **caudal approach** provides equal exposure of the acetabulum and does not require creation of a femoral osteotomy. The superficial gluteal muscle is isolated, incised at its insertion, and reflected dorsally. If necessary, the obturator and gemelli muscles are incised at their insertion at the trochanteric fossa, are tagged and retracted caudodorsally together with the sciatic nerve. After the fracture is stabilized, the internal obturator and gemelli muscles are sutured to the their insertion using a tunnel technique into the fossa intertrochanteric area. Inward rotation of the femur allows visualization of the craniodorsal area of the acetabulum.

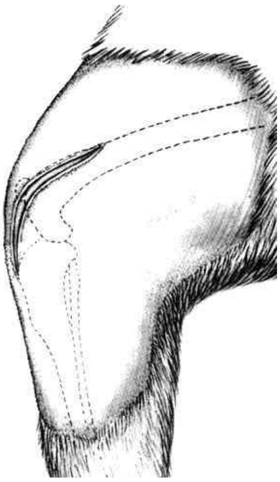
Dorsal approach

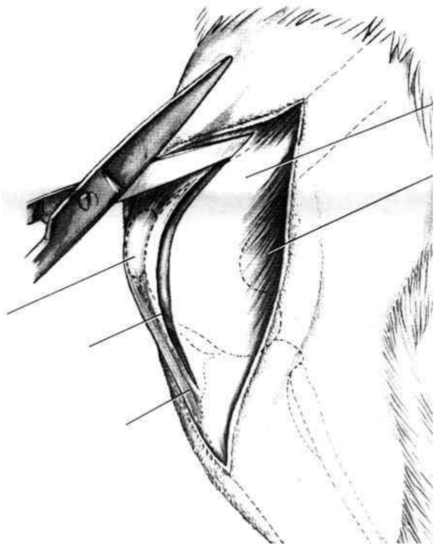
The **ventral approach** offers access to the ventral aspect of the femoral neck and head and the ventral aspect of the acetabular fossa. It is recommended for femoral head and neck excisions and femoral head fractures in dog and cat. The femoral artery and vein have to be protected. The pectineus muscle is transected near its origin on the pubic bone. Retraction of the iliopsoas cranially and the adductor and the obturatorius nerve caudally exposes the acetabulum.

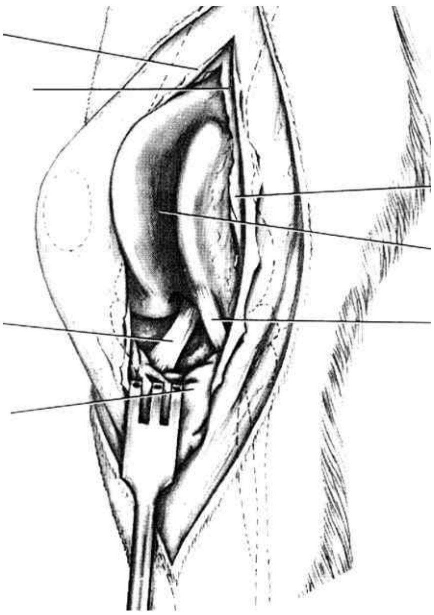
Ventral approach

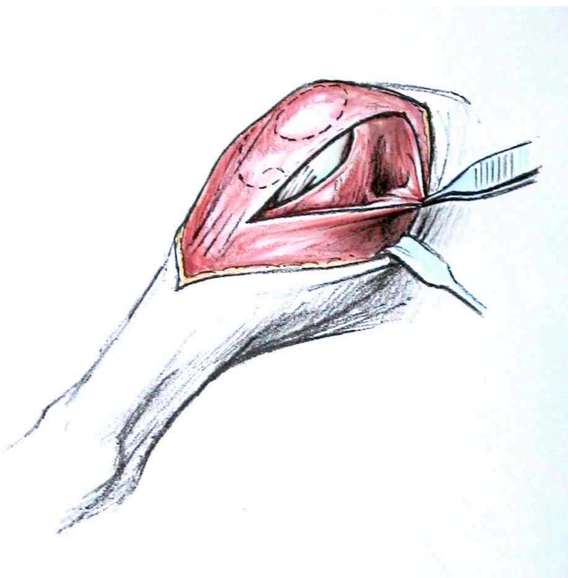
## 1.3.2 Lateral approach to the stifle joint

The approach can be performed from the medial or the lateral side. We normally approach laterally. The skin is incised from the laterodistal third of the femur to the middiaphysis  of the tibia. The fascia lata is incised along the cranial side of the biceps muscle, then extended to the margo cranialis tibiae.  The joint capsule is incised at the same level as the fascia. Care must be taken to not sever the intraarticular tendon of the long digital extensor muscle. The incision is extended to the supratrochlear area. The patella is then luxated medially in extended stifle position und held in place by flexion of the joint. The fat pad is excised and the joint inspected under retraction of the patellar ligament.









### 1.3.3 Lateral approach to the shoulder joint

The most important indication for a caudal approach to the shoulder joint is a osteochondrotic lesion in the caudocentral area of the humeral head. An OCD is found in both shoulder joints in 27 % to 68 % of the cases. The dogs develop the disease between the age of 6 to 12 months. OCD is a general developmental skeletal disease. It is presumably caused by genetic predisposition, rapid growth and overnutrition (quantity, Calcium) in large and giant breed dogs. OCD lesion may be found elsewhere on the skeleton (shoulder, elbow, stifle, tarsus). The treatment consists in removal of the fragment, surgical curettage of the lesion and adjusting general management and feeding of the dog. Shoulder OCD has a favourable prognosis.

The caudal approach to the shoulder joint requires no tenotomies. However, the axillary nerve must be spared. A good visualisation of the joint is achieved. With a mosquito, even cranial parts of the joint and the bicipital tendon sheet can be explored. Alternatively, the shoulder joint can be approached with an arthroscope and the OCD lesion can be treated through an instrumental portal.

Technique

1. Incise the skin from midscapula to midhumerus
2. Incise the subcutaneous fat and identify the following muscles: scapular part and acromial part of the deltoid muscle, lateral and long head of the triceps muscle
3. Incise the fascia between deltoid and triceps muscle
4. Retract the deltoid muscle and identify the muscular branch of the axillary nerve and the caudal humeral circumflex vein.
5. Retract the teres minor muscle cranially, the axillary nerve is now seen
6. Use a Penrose drain to protect the axillary nerve and gently move it caudally or craniodistally. Accompanying vessels are also retracted.
7. Incise the joint horizontally, about 5 mm distal to the glenoid rim
8. Explore the shoulder joint by retracting the joint capsule and inward rotation of the leg. With different flexions angles of the forelimb, the whole joint is visualized.

9. Curette the OCD lesion with a sharp spoon. Sclerotic bone is treated with osteostyxis in order to promote bone healing.
9. Close the joint with single sutures on the joint capsule, the intermuscular fascia, the subcutis and the skin.

### 1.3.4 Approaches to the elbow joint

The indications for the **craniolateral approach** are condylar and intercondylar fractures. Perfect anatomical reduction of the fractured articular surfaces with rigid fixation and movement of the elbow is important for the best functional results. This approach gives good visualization to the fracture area and exposure of the joint surfaces. Although it is proximal to the main area of exposure, it is well to note the location of the radial nerve.

Technqique:

1. The skin incision extends from the distal third of the humerus to the proximal third of the radius. The incision passes slightly caudal to the lateral condyle. The subcutaneous fascia is incised on the same line.
2. An incision is made through the deep fascia near the cranial border of the triceps muscle and is continued distally over the extensor muscles. Pay attention to the radial nerve, which is cranioproximal to the incision!
3. An incision is started distally in the intermuscular septum between the extensor carpi radialis and the common digital extensor muscles. This incision continues proximally into the periostal origin of the distal half of the extensor carpi radialis muscle.
4. The extensor carpi radialis muscle is elevated from the bone and underlying joint capsule, and the capsule is opened with a L-shaped incision. Care must be taken to protect the cartilage of the condyle.

The main indications for a **medial approach** to the elbow joint are the osteochondritis dissecans (OCD) of the medial humeral condyle and the ununited or fragmented medial coronoid process (FCP), which are part of the elbow dysplasia complex. The simple muscular-separating approach gives adequate exposure for a fragmented medial coronoid process. Nowadays, arthroscopy is the gold standard for elbow exploration.

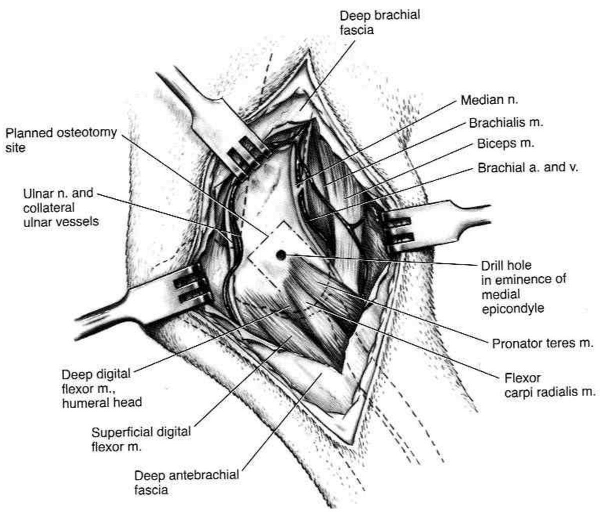
Technique:

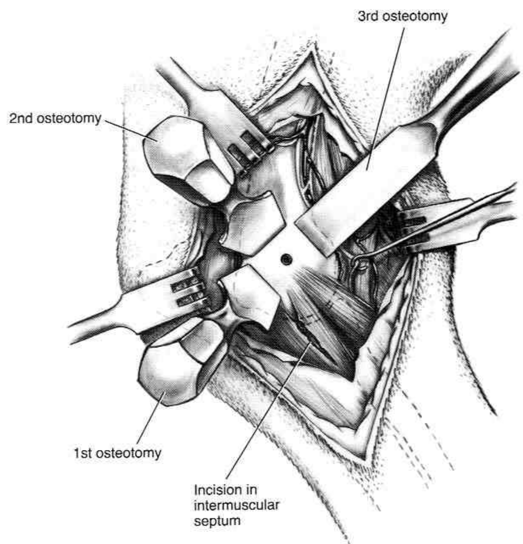
1. The skin incision starts proximal to the elbow joint and extends to proximal third of the ulna. Deep antebrachial fascia is incised on the same line as the skin and retracted to expose the flexor muscle group. Protect the ulnar nerve during the fascial incision and elevation.
2. The division of the flexor carpi radialis and deep digital flexor muscles is done by blunt dissection. The intermuscular incision can alternatively be made between the pronator teres and flexor carpi radialis muscles.
3. Strong retraction between the muscles exposes the joint capsule, which is incised parallel to the muscles. Protect the underlying articular cartilage when making this incision.
4. Exposure of the medial coronoid process may require extension of the joint capsule incision parallel to the trochlear notch of the ulna, but the incision should not cross the medial collateral ligament.
5. Visualization of the medial coronoid process is facilitated by strong pronation and abduction of the antebrachium to open the joint on the medial side.

For a good visualization of an OCD lesion of the medial condyle of the humerus a **medial epicondylotomy** is preferred.

Technique:

1. The skin incision is centered on the medial humeral epicondyle and follows the humeral shaft proximally and the shaft of the ulna distally. The subcutaneous fat and the deep antebrachial fascia are incised on the same line. Be aware of the neurovascular tissues deep to the fascia.
2. The osteotomy should include all of the origin of both the pronator teres and flexor carpi radialis muscle from the adjacent digital flexor muscles. A suitable glide and tap hole should be drilled now, just distal to the epicondyle.
3. The incisions 1 und 2 are first made by an osteotome to a depth of approximately 5 mm, and then incision 3 is made parallel to the surface of the condyle, taking care not to include articular cartilage.
4. The osteotomized bone with attached muscles and collateral ligaments can be retracted distally after incising the joint capsule.
5. The osteotomized epicondyle is reattached to its origin by a lag screw.



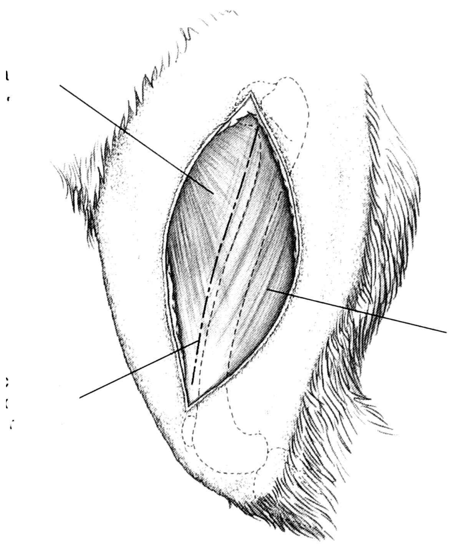
## 1.4 Approaches to the long bones

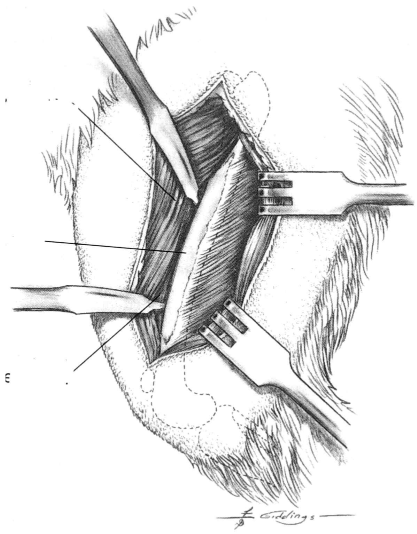
### 1.4.1 Lateral approach to the femur

The patient is laid down in lateral recumbency. The skin is incised from the major trochanter distally until the femur condyles along the cranial border of the femur.

The underlying fascia lata must be incised directly cranial to the biceps muscle. The biceps muscle is retracted caudally. The sciatic nerve lies directly underneath the biceps muscle.

The femur is now visible. The quadriceps muscle must be retracted cranially. The periosteum and some parts from the origin of the quadriceps muscle may be detached.





### 1.4.2 Medial approach to the tibia

The patient is positioned in slight oblique lateral recumbency with the affected leg directly onto the table and abducted.

The skin is incised alongside the medial plane of the tibia. In the proximal region, the medial collateral ligament is avoided. In the distal third, the saphenous artery and vein cross the tibia and should be identified an retracted. No other structure impedes the surgical approach.

## 1.4.3 Lateral approach to the humerus

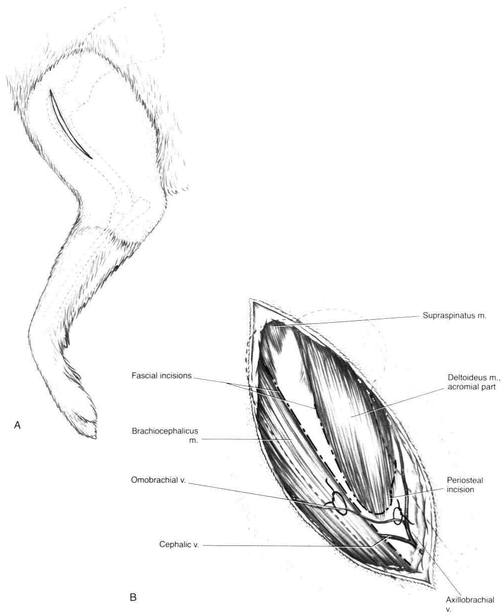
The lateral approach is indicated in proximal and midshaft Humerus fractures.

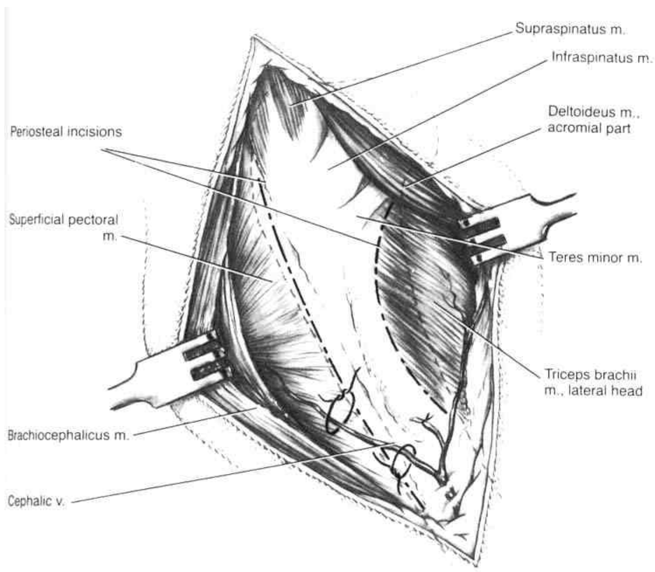
The animal is in dorsal recumbency. The skin is incised along the Humerus, from the tuberculum majus to the lateral epicondylus.

The superficial fascia is incised in the same manner as the skin. The superficial cephalic and omobrachial vein are ligated.

The deep fascia between the lateral caput of the triceps muscle and the brachiocephalic muscle is incised. The bone is then found in the depth. Be aware of the radialis nerve, which crosses the Humerus between these two muscles together with the brachialis muscle.

The brachialis muscle and the radial nerve are retracted caudally or, in case of the distal fracture, towards cranial.



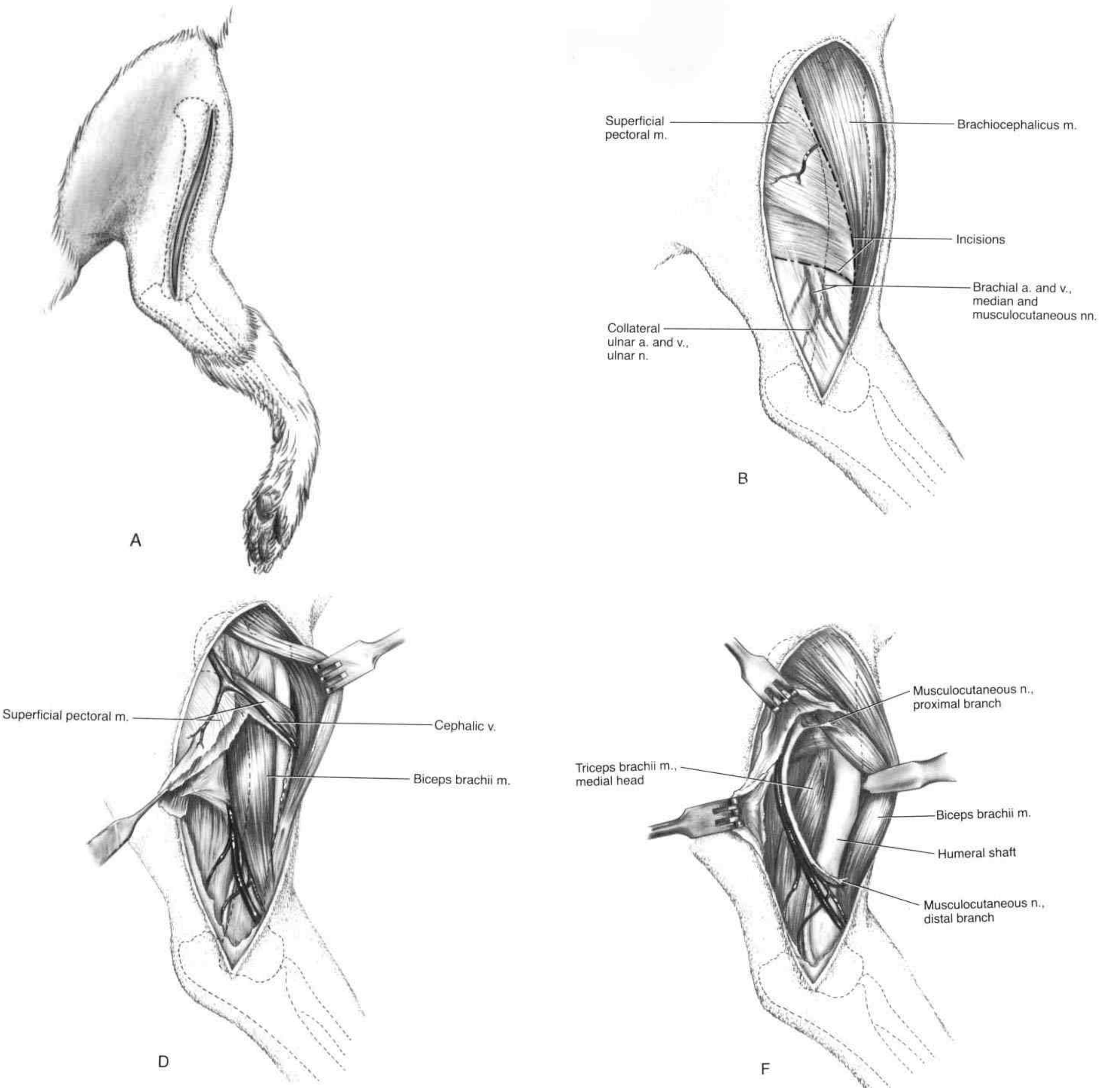




## 1.4.4 Medial approach to the humerus

The medial approach is indicated in all midshaft and distal humerus fractures. The animal is positioned in oblique lateral recumbency with the affected leg onto the table. The bone is accessible and not so curved as on lateral aspect, but there are more vessels and nerves on the medial aspect.

After incision of the skin, the brachiocephalicus and pectoral muscles are separated. The biceps muscle sis identified underneath. Either cranial or caudal retraction of the muscle offers easy access to the humerus.

Important structures to be preserved are branches of the musculocutaneus and the median nerve and the brachial artery and vein.



### 1.4.5 Medial approach to the radius

The patient is placed in lateral recumbency, the affected leg onto the table. Depending on the location of the fracture, the skin incision is made between the medial humeral epicondyle and the medial styloid. The cephalic vein is identified and protected.

The fascia is incised between the radial carpal extensor und pronator teres muscles. Care must be taken to avoid the brachial artery and vein, the median nerve and branches of the radial nerve.

# 2 Selected topics from joint surgery

## 2.1 Patellar luxation

### 2.1.1 Biomechanical aspects

The lateral or medial transposition of the tibial tuberosity as a part of the treatment for patellar luxation can be combined with a cranialisation. This is achieved by oblique osteotomy of the tibial tuberosity (fig. 1)  and fixation a by tension band. The whole procedure for the treatment of patellar luxations includes also sulcoplasty of the femoral groove and additional soft tissue reconstructions.

The cranialisation of the tibial tuberosity offers the following advantages:

(1) The compressive force transmitted from the patella to the femur is reduced (fig. 2). In osteoarthritis of the patellofemoral joint and in chondromalacia of the patella, cranial displacement of the patella tendon  consistently relieves pain.

(2) A cranial cruciate ligament rupture can be prevented. Recent studies of the biomechanics of the stifle reveal that an advancement of the tibial tuberosity reduces the force of the cranial cruciate ligament.

(3) The patellar tendon remains straight. In several other techniques, where the tibial tuberosity is fixed on the medial or lateral side of the tibia, the tendon becomes twisted. The patella and the underlying femoral cartilage are unphysiologically loaded, which causes anterior knee pain.

Figure 1:  Lateral (x) and cranial (y) advancement of the tiibial tuberosity after oblique osteotomy (O) in case of medial patellar luxation.

Figure 2: Effect of cranio-caudal displacement of the tibial tuberosity on the compressive force of the patella onto the femur: cranialisation reduces the compressive force.

### 2.1.2 Preoperative planning

The indication for surgical treatment of canine and feline patellar luxation is based on the clinical signs and the degree of patellar luxation. A tibial crest osteotomy and a femoral sulcoplasty is necessary to reestablish normal stifle function. In individuals younger than 5 months, a subchondral sulcoplasty, in individuals older than 5 months, a wedge sulcoplasty is performed.

Postoperative pain can be relieved, when the retropatellar force is reduced. This is done by a cranialisation of the osteotomized tibial crest. An oblique osteotomy is performed, which allows vast correction of patellar luxation and also cranial advancement of the tibial crest and of the patellar ligament. For medial patellar luxations, the caudal landmarks for the osteotomy are the cranial border of the medial meniscus and the tendon of the extensor digitalis extensor muscle (Fig. 1).

In addition to these bony corrections, soft tissue reconstructions aid in the postoperative period, but should not be used as sole method of therapy.

### 2.1.3 Technique (medial patellar luxation)

1. Clip the hindleg including the tarsal area and place the animal in dorsal recumbency
2. After the skin incision, arthrotomy is made on both lateral and medial aspect, respecting the parapatellar fibrocartilages. Luxate the patella
3. Inspect the stifle (ligaments, menisci, chondromalacia, deformities, synovitis)
4. Identify the tuber Gerdy laterally and the cranial border of the medial meniscus as landmarks for the osteotomy.

Figure 3: Medial view of the osteotomy of the tibial crest

5. Use a hobby saw to make an oblique osteotomy cranial to the landmarks and extend it further distally (Fig. 1., Fig. 3). Reflect the osteotomized tibial crest proximally.
6. Wedge sulcoplasty: Mark the beginning of the wedge sulcoplasty with a scalpel blade. The highest point of the sulcus must remain intact. Carefully plan the thickness of the additional slice to be removed. Use a X-ACTO saw to create the wedge. Be careful not to damage the origin of the posterior cruciate ligament. Remove an additional slice on the side of patellar luxation (Fig. 4).
7. Break the sharp edge at the basis of the wedge and further deepen the cut on the femur with a rongeur. Replace and fit the wedge until it is stable and a satisfactory sulcus is obtained. The supratrochlear entrance of the sulcus may be enlarged with filing if to narrow.

8. Replace the patella and define the amount of lateral tibial crest transposition without twisting the patellar ligament. Fix the tibial tuberosity with a tension band wire using two 0.8 (cats) to 1.6 mm (big dogs) pins and 0.6 mm (cats) to 1.2 mm (big dogs) cerclage wire in figure 8 pattern (Fig. 5).
9. Soft tissue reconstructions (as far as needed, possibilities):
   - Medial muscle release: transsect the M. sartorius and the M. vastus medialis off the patella and fix it further proximal to the rectus femoris
   - Lateral imbrication: fascia lata is closed with an overlapping suture pattern
   - Medial capsule and retinaculum incisions may be left unsutured
   - Derotational suture: place a suture around the lateral fabella and in the patellar ligament to enhance lateral tension in case of medial patellar luxation with excessive inward rotation of the tibia
10. Postoperative care: Put the leg in a bandage for 3 – 7 days and force physical therapy thereafter. Control the repair with x-rays immediately postoperative, after 6 weeks and 3 months.

Figure 4: Wedge sulcoplasty. An additional slice is removed on the side of luxation

Figure 5: Tension band wire for fixation of the osteotomized tibial crest

## 2.2 Cranial cruciate ligament rupture

### 2.2.1 Anatomy

The cranial cruciate ligament (CrCL) runs from the caudomedial part of the lateral condyle of the femur diagonally across the intercondylar fossa to the cranial intercondyloid area of the tibia. The caudal cruciate ligament (CaCL) runs from the lateral surface of the medial femoral condyle caudodistally to the lateral edge of the popliteal notch of the tibia. The cruciate ligaments consist of two anatomically and functionally different parts. The CrCL has a stronger caudolateral and somewhat smaller craniomedial part. In extension of the stifle joint, both parts are taut. In flexion, the caudolateral band is loose whereas the craniomedial band is taut. The cruciate ligaments receive their blood supply from vessels of the synovial tissue ensheating them.

As the stifle flexes, the lateral collateral ligament relaxes as a result of its attachments. This allows cranial displacement and internal rotation of the tibia. The reverse occurs in extension.

The lateral and medial menisci are semilunar, fibrocartilaginous discs. The lateral meniscus is slightly greater than the medial one. The transverse intermeniscal ligament is a band between their cranial horns. The lateral meniscus has a cranial and a caudal tibial ligament and a meniscofemoral ligament. This makes it more mobile with repect to the femur. The medial mensicus has a cranial und caudal tibial ligament and an attachment to the medial collateral ligament. This causes less mobility with respect to the femur and full load transmission may be placed on the caudal rim of the medial meniscus.

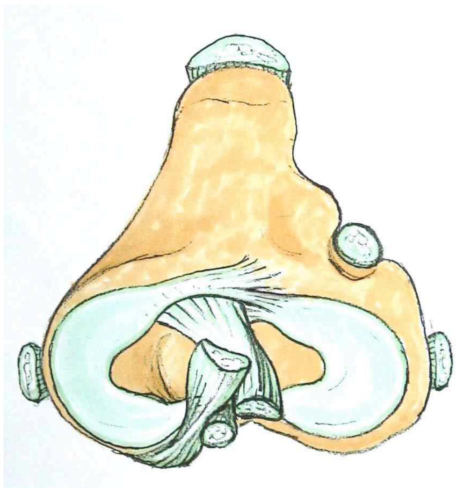


Figure 1: Illustration of the tibia plateau in a proximodistal view, showing the course of the CrCl and CaCL.

It is the craniomedial part of the CrCL which resists primarily against hyperextension and cranial displacement of the tibia. Secondary constraints againts cranial movement are provided by the joint capsule, the menisci, the collateral ligaments, the muscle forces and the shape of the tibial plateau (Fig. 1).

### 2.2.2 Pathophysiology

Traditional explanations of the pathophysiology of cranial cruciate ligament rupture in dogs included trauma or multiple traumas to the stifle joint. This was derived from human orthopedic surgery, where this correlation is obvious. However, there are several facts, which speak against it. (1) histologic examinations of ruptured CrCL showed sign of degeneration (Geyer, 1966), (2) the anamnesis mostly demonstrates first partial, then complete ruptures, (3) there is seldom a heavy impact onto the stifle joint before the rupture is diagnosed, (4) stifle biomechanics is different in humans and in dogs, (5) there are breed predilections for CrCL ruptures (Whitehair, 1993), (6) the heavier the dog, the earlier the rupture, (7) the contralateral stifle is affected in many cases, and (8) even in so called “acute ruptures”, we see osteoarthrotic signs on the stifle radiographs.

It was due to Barclay Slocum (1993), that the pathophysiology of the CrCL rupture was reassessed by the introduction of muscle forces. Further investigations and the success of the newly developed methods to treat CrCL rupture have led the following concept, which is given in a simplified form.

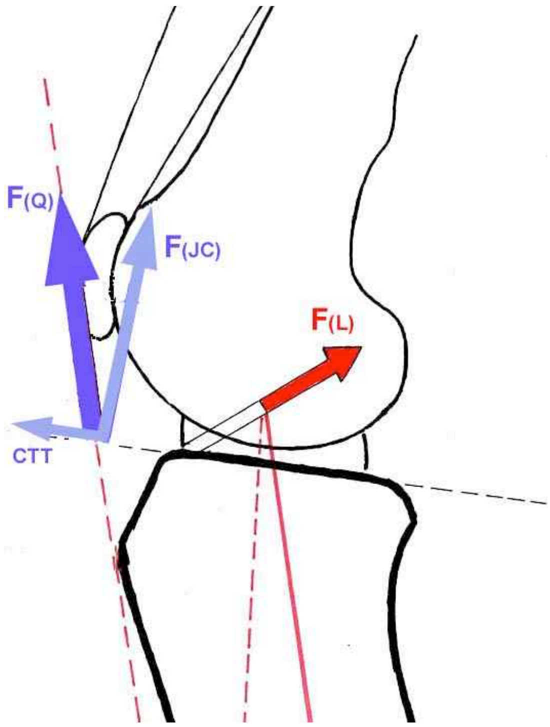


Figure 2: Schematic presentation of the main forces in the canine stifle joint. F(Q) = Force of the quadriceps muscle, F(JC) = Joint compressive force, CTT = cranial tibial thrust, F(L) = counterforce of the CrCL. F(Q) = F(JC) + CTT.

The quadriceps muscle, together with the body weight, is the main force acting on the stifle joint. It inserts on the tibial tuberosity by way of the patellar ligament. The angle between the direction of the quadriceps force and the tibial plateau is dependent on the standing phase of the hindlimb, but is mostly higher than 90°. According to the vector analysis, the quadriceps force can be split up into a force perpendicular to the tibial plateau and a resulting force towards cranial. This latter force is called cranial tibial thrust (CCT). It is counteracted by the CrCL and other passive elements in the stifle joint such as collateral ligaments, joint capsule or caudal horns of the menisci (Fig. 2).

In small dogs, the CTT is well balanced by the CrCL. However, there are factors, which may increase the CTT. These are overweight, large breed dogs and overextension in the stifle joints. If we look carefully to the possible candidates for a CrCL rupture, we can support these reflexions: overweight Labrador retrievers, Rottweilers, Newfoundland dogs, Mastiffs, Bullterriers. Finally, it is only a question of time, until the CrCL is partially torn, and ends up with complete tearing. The more negative factors are present, the earlier the process begins.

One may argue, why some large breeds do not have an increased risk for CrCL ruptures (e.g. Greyhounds, Malamutes). The explanation is rather philosophic than scientific. It is the human being, which creates canine breeds, that were not foreseen to be as large or heavy, as they are forced to. Mother nature would have never allowed such a development and rather would have produced smaller and leaner dogs.

### 2.2.3 Diagnosis

The typical anamnesis includes initial non-weight bearing lameness, clinical improvement after some weeks and clinical signs of degenerative joint disease. Stifle laxity is palpated in upright position and lateral recumbency. A positive cranial drawer sign (Fig. 3) or tibia compression test is diagnostic for CrCL rupture. Increased internal rotation and crepitus are the most common associated findings. Incomplete CrCL ruptures do not always lead to a positive drawer sign or tibia compression test. Eventually, pain in hyperextension or a slight drawer sign in flexion my be elicted. False negative joint laxity results are obtained in dogs with heavy muscle tone or severe degenerative joint disease with capsule fibrosis. In contrast, young dogs normally have some degree of stifle laxity.

Radiographs of the stifle are taken to rule other abnormalities than a CrCL rupture. Signs associated with CrCL may be joint effusion (Fig. 4), cranial displacement of the tibia, bulging of the joint capsule, calcification after meniscal or ligament injuries, and signs of degenerative joint disease. Radiographs of the entire tibia are taken to plan the surgery and to give a prognosis concerning long term outcome. Synovial fluid assessment, scintigraphy and positive contrast arthrography add little information to the diagnosis, whereas MRI is the method of choice in human knee disorders. Partial tears of the CrCL are best diagnosed with arthroscopy or explorative arthrotomy.

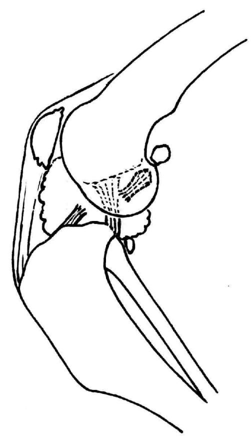


Figure 3: Illustration of the instable stifle joint, when performing a drawer test or when the dog is walking.

Figure 4: Laterolateral radiograph of a stifle joint with a CrCL rupture. Note the joint effusion.

### 2.2.4 Therapy

As mentioned above, there is a biomechanical failure causing CrCL ruptures. Simple ligament prosthesis, either intra or extraarticular, will by time lead to the same catastrophic situation as it happened, when the original CrCL begun to fail. Therefore, it is strongly recommended to change biomechanics. This can be done either with a Tibia Plateau Leveling Osteotomy (TPLO according to Slocum) or with a Tibial Tuberosity Advancement (TTA). The Tibia Wedge Osteotomy (TWO) is less advantageous. Biomechanical corrections are performed on heavy dogs, overweight dogs and in bilateral CrCL ruptures. Dogs less than 10 kg bodyweight still can be operated with ligament prosthesis with a good rate of success.

### 2.2.5 Extracapsular suture techniques (Flo, combined with Harrison)

The approach can be performed from the medial or the lateral side. We normally approach laterally (Fig. 5). The skin is incised from the laterodistal third of the femur to the middiaphysis of the tibia. The fascia lata is incised along the cranial side of the biceps muscle, then extended to the margo cranialis tibiae. The joint capsule is incised at the same level as the fascia. Care must be taken to not sever the intraarticular tendon of the long digital extensor muscle. The incision is extended to the supratrochlear area. The patella is then luxated medially in extended stifle position und held in place by flexion of the joint. The fat pad is excised and the joint inspected under retraction of the patellar ligament.

A heavy polyester suture is placed in figure 8 configuration extracapsular around the lateral fabella and through a tunnel in the tibial tuberosity close to the proximocranial end of the tibia. One suture is placed in the same manner around the medial fabella and a separate tunnel in the tibia, which adds stability to the reconstruction (Fig. 6). The property of the suture material used leads to a periarticular inflammation and scar tissue formation. In case of suture material failure, the scar tissue should hold the stifle stable. An aponeurotic sling helps to protect the extracapsular repair and prevent meniscal damage in the early postoperative period.

Step by step:

1. Lateral approach to the stifle joint (Piermattei 1993)
2. Exploration of the stifle joint. The damaged ACL is cut, meniscal lesions are excised. The cranial horn of the medial meniscus should be left intact. A synovectomy is performed.
3. Closure of the joint capsule.
4. Preparation of the fossa extensoria, two holes are drilled into the tibial tuberosity in the proximocranial part of the tibia, close to the insertion of the patellar ligament.
5. A heavy non-resorbable braided suture material (e.g. Polyester) is used for the extracapsular repair. It is placed around the lateral fabella, then crossed in figure 8,

passed through the tunnel and taken back to the lateral side underneath the patellar ligament.

6. An similar maneuver is performed at the medial side using the more distal hole and avoiding damage to the suture material already in place.
7. The lateral sutures are tied strong in slightly flexed stifle position and outward rotation of the extremity. The medial suture is also tied.
8. The medial and lateral fasciae are prepared far proximally (Harrison technique). They are imbricated cranial to the tibia with horizontal mattress sutures. The fascia is imbricated also on the lateral side of the stifle.
9. The limb is bandaged for ten days. Physical therapy and analgesics help in the postoperative period.

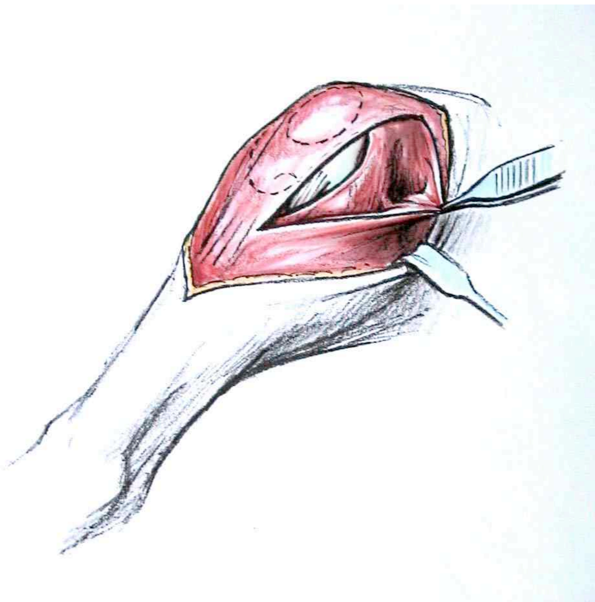


Figure 5: Lateral approach to the stifle joint through a lateral or medial skin incision and lateral incision into the fascia lata and the joint capsule.

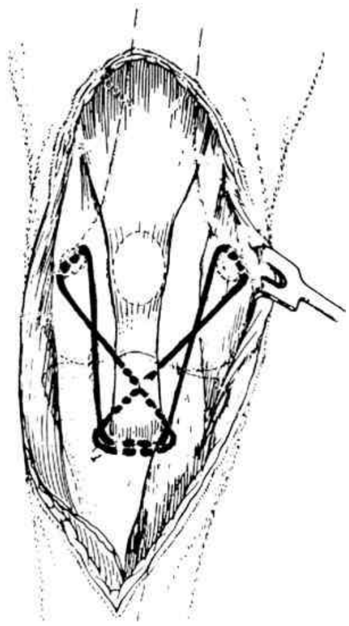


Figure 6: Flo's procedure with extracapsular prosthesis on lateral and medial side

**2.2.6 Tibial Tuberosity Advancement (TTA according to Montavon and Tepic, Fig. 7)**

The procedure presented here consists in advancing the tibial tuberosity, in order to position the patellar ligament perpendicularly to the tibial plateau, thereby reducing the tibiofemoral shear force (CTT) to zero and easing the function of the deficient CrCL. The lesser invasive technique reduces operative time and perioperative morbidity. Respecting the normal range of flexion of the stifle should make a meniscal release, hence a loss of intraarticular caudal support, not necessary. Decreased retropatellar pressure could alleviate the sulcus chondromalacia present in about 30% of the cases. These advantages should improve the short and long-time results of the surgical treatment of cranial cruciate deficient stifle.

Mediolateral radiographs of the stifle in extension, avoiding the cranial drawer phenomenon in the presence of total rupture of the cranial cruciate ligament are necessary to figure out the angle necessary to bring the patellar ligament perpendicularly to the tibial plateau. The patellar ligament is represented by its cranial border, the orientation of the tibial plateau by a line passing through both tibial origins of the cranial and caudal cruciate ligaments.

Arthroscopy or medial arthrotomy is performed in case of total cranial cruciate ligament rupture to explore the stifle joint and treat eventual meniscal lesions. Transverse osteotomy of the tibial tuberosity is carried through its distal extremity to the cranial borders of the menisci. A bone spacing structure of desired size is inserted into the distracted osteotomy in order to advance the tibial tuberosity, giving its new position to the patellar ligament. The tibial tuberosity is fixed to the tibia with a special plate in tension band mode (Fig. 8). The wound is closed in appositional manner after mobilizing the edges in order to cover the implants.

A postoperative bandage is not necessary. Clinical results are satisfactory as documented by force plate gait analysis. Return to normal locomotion is straight forward, even in sport or hunting dogs. Recovery time is between 6 weeks and 3 months. Progression of stifle osteoarthritis is strongly slowed down.

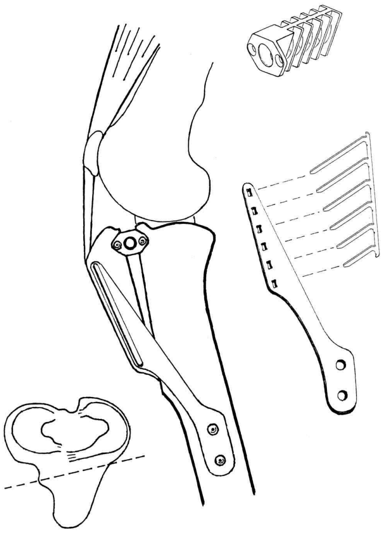


Figure 7: Schematic representation of the TTA and its implants.

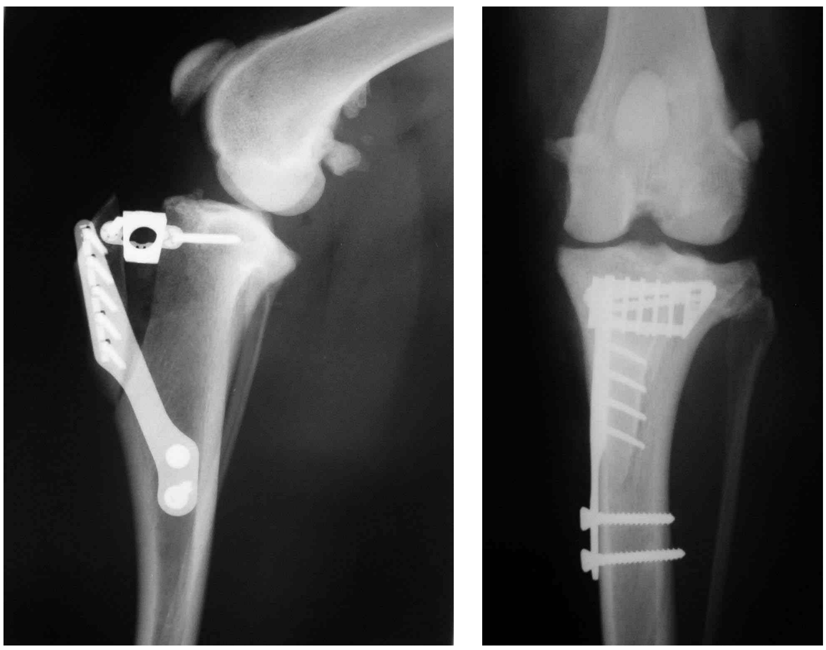


Figure 8: Postoperative radiographs of a 8 year old Labrador Retriever after TTA surgery.

## 2.3 Hip luxation

### 2.3.1 Introduction

Surgical approaches to the hip joint include the craniodorsal approach, the caudal approach, the dorsal approach via a trochanteric osteotomy and the ventral approach. The craniodorsal approach allows visualization of the craniodorsal aspect of the hip joint and is indicated for femoral head and neck excision, for cranial acetabular fractures, for femoral head and neck fractures, for installation of total hip prosthesis and for open reduction and internal fixation of coxofemoral luxations.

Coxofemoral luxations are usually the result of external trauma, such as hit by car, which leads to failure of the joint capsule and the round ligament. The femoral head may dislocate in a craniodorsal direction, the most frequent form, or in a caudodorsal or ventral direction. Hip luxations can be accompanied by femoral head or acetabular fractures.

Closed reduction of the hip joint followed by the use of an external support like the Ehmer sling may be unsuccessful due to persisting remnants of the round ligament, the joint capsule or blood clots in the joint or due to coexisting hip dysplasia. These conditions require open reduction and internal fixation. Internal fixation is also advised in animals with concurrent injuries of another leg, which makes the application of an Ehmer sling impossible. Numerous methods have been described for internal fixation after reduction of a coxofemoral luxation. An extraarticular stabilization technique was described by B. Slocum, consisting of a suture sling between the greater trochanter and the cranial aspect of the acetabulum. This sling, like the Ehmer sling, holds the hind leg in internal rotation, thus preventing reluxation in the postoperative period. The final joint stability is due to joint capsule healing and formation of periarticular fibrosis.

### 2.3.2 Surgical Technique

Approach (see above):

- Skin incision from the level of the greater trochanter, along the cranial border of the shaft of the femur, to half of the length of the femur
- Incision through the superficial leaf of the fascia lata, along the cranial border of the biceps femoris muscle and caudal retraction of the muscle
- Incision of the deep leaf of the fascia lata distally and continuing the incision proximally between the cranial border of the superficial gluteal and tensor fascia latae muscle
- Dorsal retraction of the superficial and middle gluteal muscles and partial tenotomy of the tendon of the deep gluteal muscle at its insertion on the greater trochanter
- Dorsal retraction of the deep gluteal muscle and preparation of the joint capsule with an periosteal elevator

- T-shaped incision of the joint capsule (if still intact) with a No. 15 blade. The “top of the T” incision is made on the distal end.

Reduction and fixation of the luxated hip

- Excision of the remnants of the round ligament and cleaning-up of the joint
- Drilling of two parallel holes with a 1,6 mm Kirschner wire through the greater trochanter (rather proximal) in a caudal to cranial direction
- Drilling of another hole ventral through the ilium, just cranial to the acetabulum, in a proximolateral to distomedial direction
- Placing of the suture sling in a figure-of-8 form through the hole in the ilium and through the two holes in the greater trochanter, without severing the ischial nerve . Depending on the size of the animal, several suture slings can be placed through the holes in the same manner.
- Suturing the joint capsule with a cruciate suture pattern
- Tying the ends of the suture sling with a gliding knot, while the leg is held in slight abduction and internal rotation
- Repair of the tenotomy of the deep gluteal muscle
- Closure of the fascia, the subcutaneous tissue and the skin using interrupted suture pattern
- Immobilisation of the hip with an Ehmer sling for 10 days
- Radiograhic control after surgery, at 3 days and 10 days postoperatively