# Cranial Cruciate Ligament Injury

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# Conflict of interest

None

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# Table of Contents




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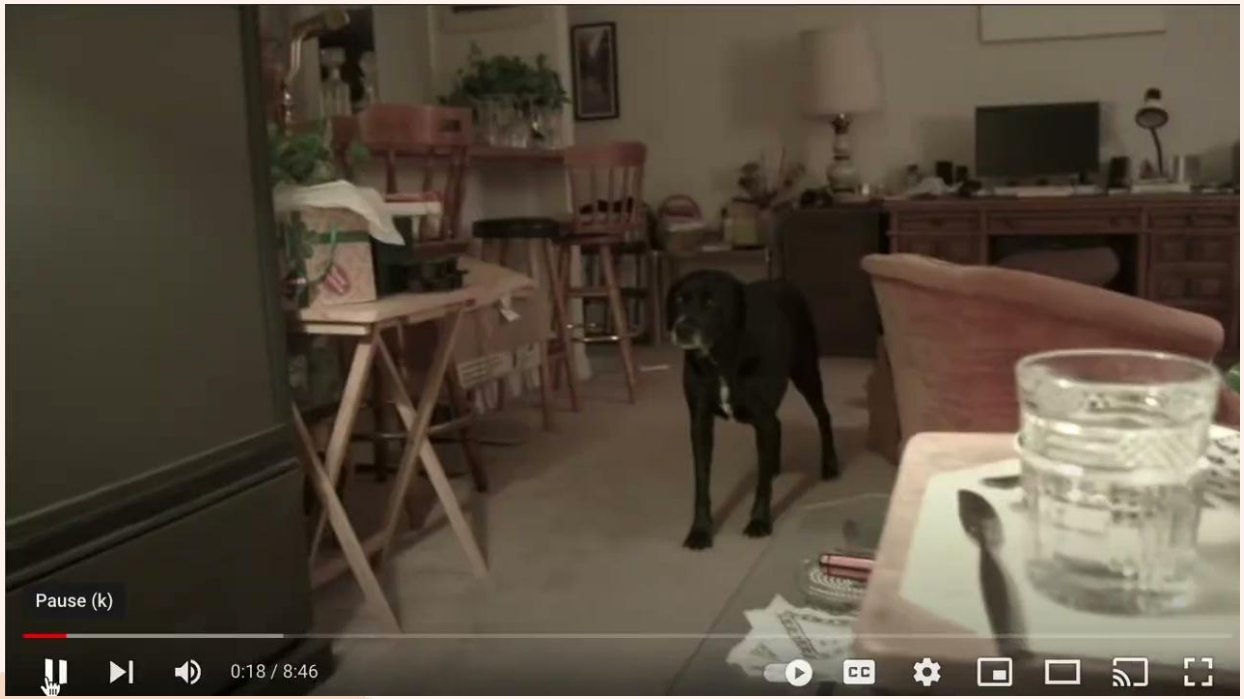
# “Simon”

- 2yr MN Labrador
- 3 months history of LHL lameness
  - Wife: Maybe he fell off a chair
  - Husband: No, nothing happened
- Owners have tried rest and medications, they want answers

# What are the most likely differentials?

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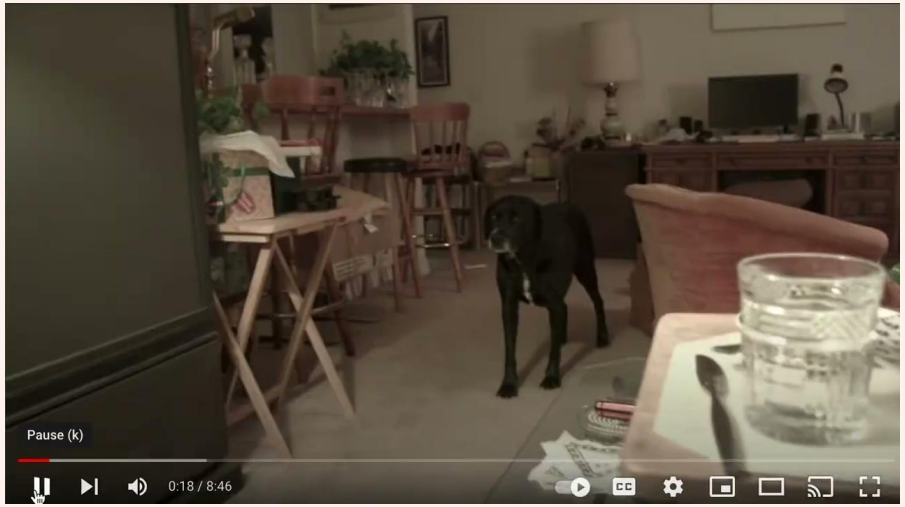


# What are the most likely differentials?

1. CCLR
2. Soft tissue injury
3. Meniscal injury
4. CdCLR
5. Coxofemoral luxation
6. Nerve root signature

# What are the most likely differentials?


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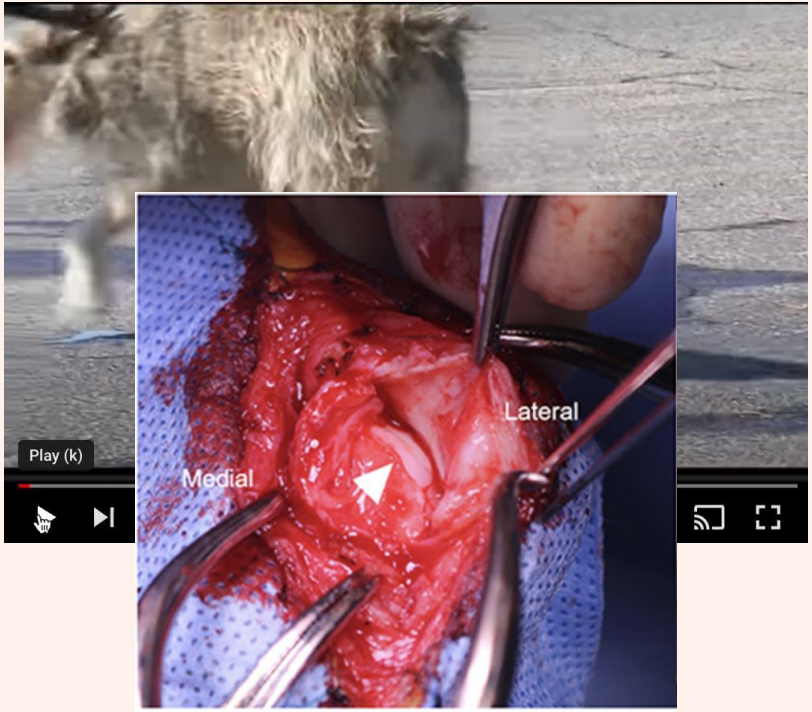
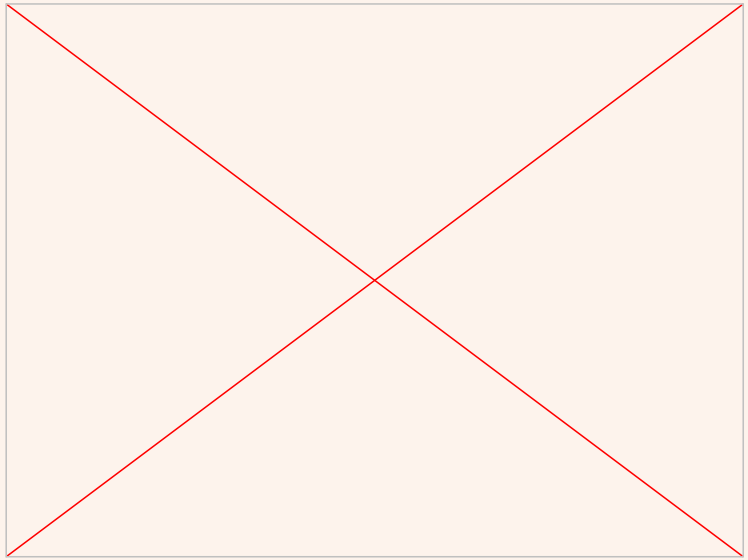
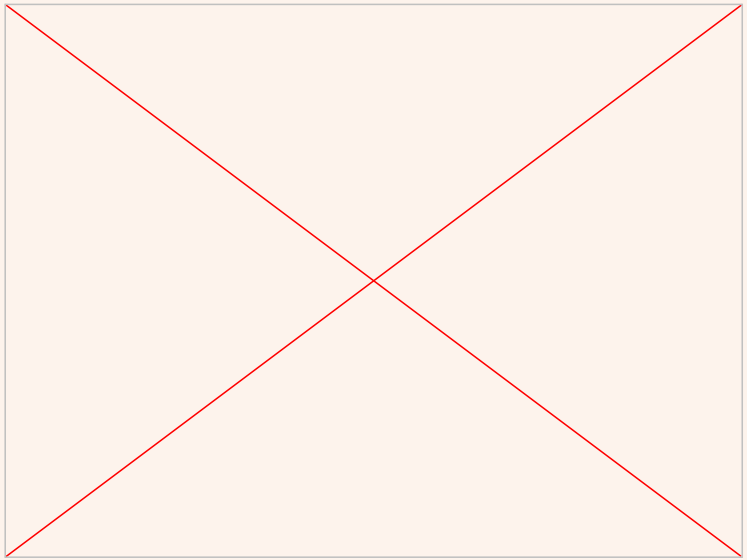



# What are the most likely differentials?

1. MPL
2. SDF luxation

# What are the most likely differentials?





# What are the most likely differentials?

1. Neuropathy
2. Stringhalt

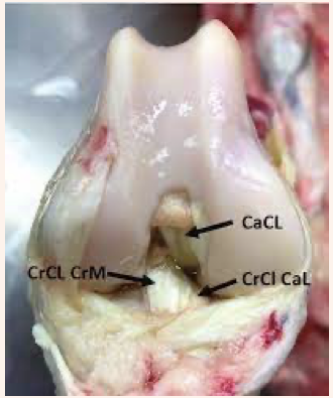
# What are the most likely differentials?

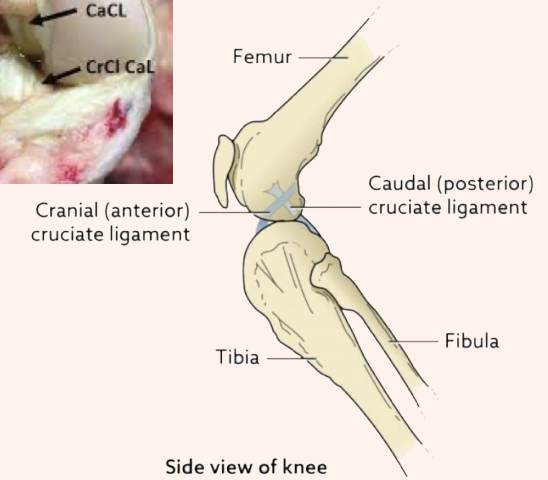
# What are the most likely differentials?

1. Bilateral CCLR
2. MPLs
3. IMPA
4. Tick-borne disease

# Anatomy of the stifle

- Cranial/Caudal cruciate ligaments
  - Contain mechanoreceptors, proprioceptors
  - Cranial cruciate ligament
    - Caudomedial lateral femoral condyle → cranial tibia
    - Two parts
      - Craniomedial
      - Caudal cruciate ligament
    - Caudal cruciate ligament
      - Craniomedial medial femoral condyle → caudal femur




Side view of knee

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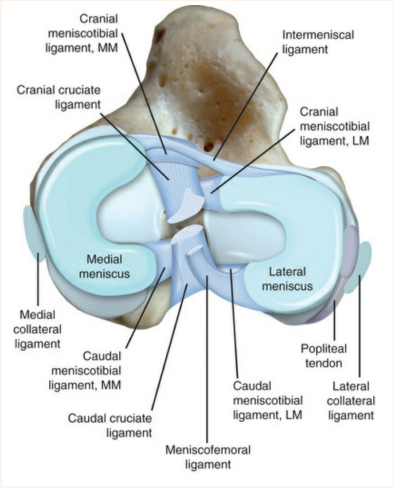
# Meniscus

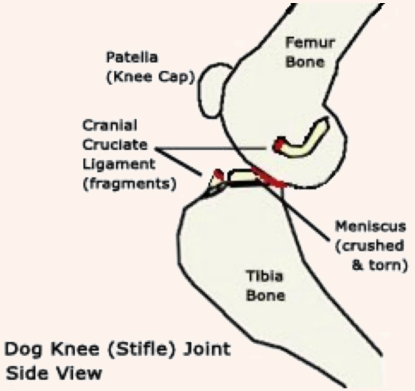
- Fibrocartilage

- Functions
  - Improve joint congruity
  - Load distribution
  - Shock absorption

# Why is the medial meniscus so susceptible?

- Why?
  - Medial meniscus is more firmly attached to tibia
    . Cranial/Caudal meniscotibial ligaments
    . Joint capsule
    . Medial collateral ligament
  - Lateral meniscus has attachments which couple it to movement of the femur
    . Cranial/Caudal meniscotibial ligament (flimsy)
    . Popliteal tendon
    . Meniscofemoral ligament
    . NOTE: no LCL and minimal joint capsule attachment (popliteal tendon interference)

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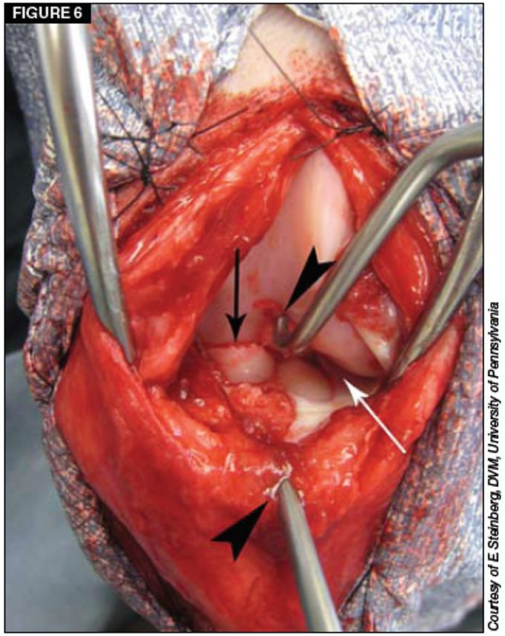
# Meniscal injury – Risk factors

- Risk factors
  - (Little known)
  - Overweight
  - Chronic CCLR
  - Complete CCLR

- Incidence -30-80%

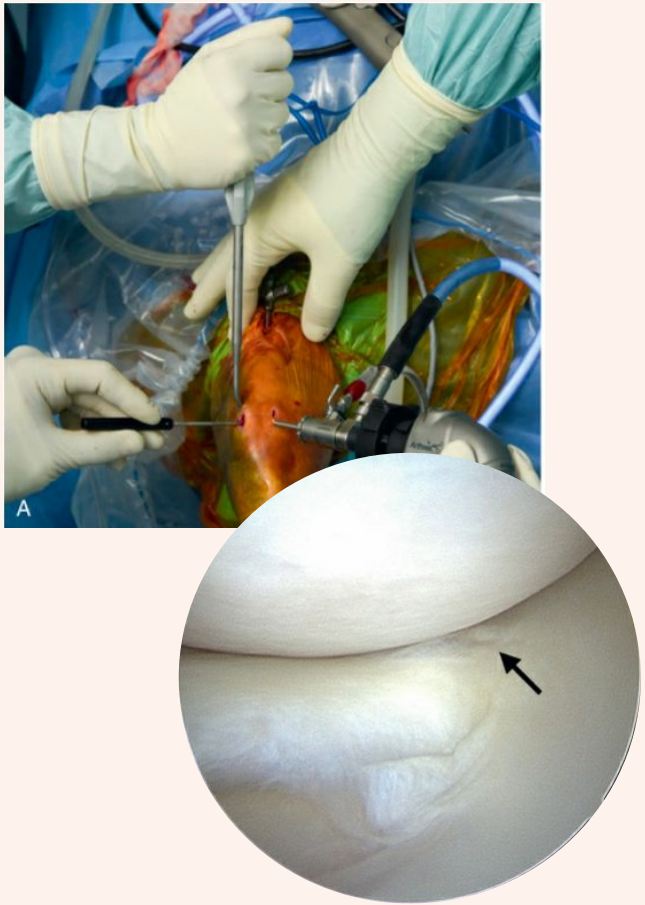



**Use of the Wallace stifle retractor.** The retractor is engaged just cranial to the origin of the caudal cruciate ligament and the insertion of the CrCL (*arrowheads*), taking care not to impinge the ligaments or impale the articular cartilage. Note the folded caudal pole injury of the medial meniscus (*black arrow*) and the caudal pole of the lateral meniscus lifting proximally due to its attachment to the femur (*white arrow*).

# Meniscal injury – Diagnosis

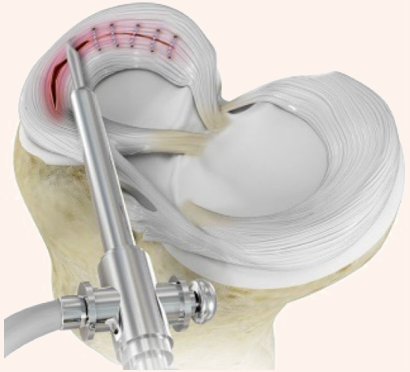
- Physical examination
  - Meniscal click – 22-25% sensitive, 89-98% specific
    . 65% of these will have bucket handle tears
  - Pain on joint flexion – 14-15% sensitive, 89-91% specific

- Imaging
  - Arthroscopy (gold santadard)
  - US – 86-90% sensitive, 78-82% specific
  - MRI – 75-77% sensitive, 100% specific
  - CT arthrography – variable sensitivity/specificity



# Meniscal injury – Treatment

- Hemi Meniscectomy
- Partial meniscectomy
- Meniscal release
  - Advantage – allows caudal displacement of medial meniscus, minimizing risk of injury
  - Location
    - Caudal
    - Midbody
  - Does not prevent postliminal meniscal injury
- Meniscal repair
  - Rare
  - Red-red meniscus only



# Meniscal injury – Treatment

- Meniscectomy will lead to osteoarthritis
- Meniscal repair v partial removal
  - Meniscal injury changes contact pressure pattern
  - Meniscal repair decreases peak contact pressure and increases contact area caused by tear
  - Partial meniscectomy does not change contact pressure/area compared with injury
  - Meniscal release (caudal or midbody) results in 140% increase in peak contact pressure, 50% decrease in contact area
- Partial meniscectomy leads to less severe changes
  - 30% radial width resection has minimal effect on biomechanics of meniscal function
  - 75% width & hemi meniscectomies will have significant impact on femerotibial contact
- Meniscus can partially regenerate from synovium

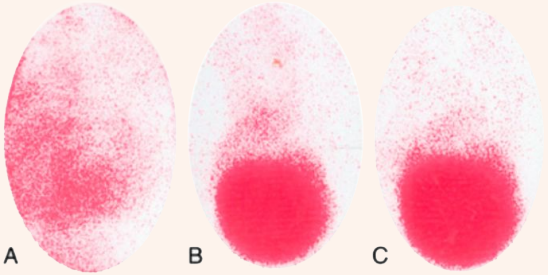



FIGURE 61.6 Pressure-sensitive films stained before medial meniscal release (A), after medial meniscal release (B), and after medial caudal pole hemimeniscectomy (C). (Reprinted with permission. From Pozzi A, Litsky AS, Field J, et al. Pressure distributions on the medial tibial plateau after medial meniscal surgery and tibial plateau levelling osteotomy in dogs. *Vet Comp Orthop Traumatol* 21:1, 2008.)

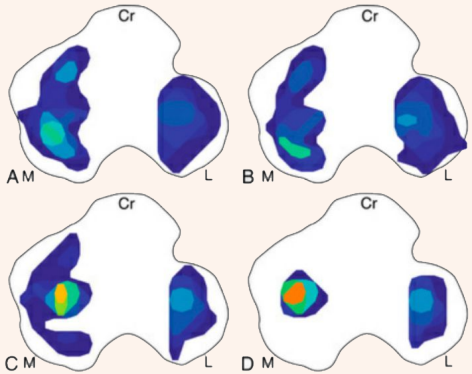



FIGURE 61.8 Contact maps for each meniscal condition of lateral *(L)* and medial *(M)* compartment of the stifle joint presented with the outlined tibial plateau. A, Intact medial meniscus. B, 30% radial width medial meniscectomy. C, 75% radial width medial meniscectomy. D, segmental medial meniscectomy. Pressure (MPa) is designated by each color on the contact maps; pressure increases from dark blue to light blue to green to orange. *Cr*, Cranial. (Reprinted with permission. From Pozzi A, Tonks C, Ling HY. Femorotibial contact mechanics and meniscal strain after serial meniscectomies. *Vet Surg* 39:482, 2010.)

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# Types of CCL injury

- Avulsion
  - Skeletally immature animals
  - Often associated with avulsion fragment
  - Treatment
    - Stabilization of small fragments
    - Epiphysiodesis

      . Surgically induced premature union of epiphysis with diaphysis

      . Goal to reduce tibial plateau angle

      . 18/22 dogs had an improved to normal gait


r/o Lateral Digital Extensor Tendon Rupture

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# Types of CCL injury

- Chronic degeneration
  - Risk factors
    - Abnormal conformation/gait
    - Obesity
    - Female > Male
    - Neutering
      - Golden Retrievers spayed/neutered before puberty @3-5x risk joint disorders
      - Labrador Retrievers spayed/neutered before puberty @ 2x risk
      - GSDs spayed/neutered <12mo @ increased risk
      - Dogs with eTPA and subsequent CLR 13.6x more likely to be neutered <6mo
    - Breed
    - Medial patellar luxation
  - Large breed dogs tend to develop CCLR at a younger age than small breed
  - Contralateral rupture 22-54%

| Increased Predisposition |
|---|
| Rottweiler |
| Newfoundland |
| Staffordshire Terrier |
| Labrador Retriever |
| Brazilian mastiff |
| Akita |
| Saint Bernard |
| Chow Chow |
| Bullmastiff |
| Bulldog |
| Boxer |

| Decreased Predisposition |
|---|
| Dachshund |
| Basset Hound |
| Old English Sheepdog |

# Physical Examination

- Pain on complete stifle extension
- Medial buttress – medial periarticular hypertrophy
- Joint effusion
- +/- Muscle atrophy/Asymmetry
- Abnormal ”sit test”

**”Puppy Drawer”**

Young dogs with a bilaterally symmetric small amount of physiologic craniocaudal tibial translation (feels like a sudden stop in 3-5mm)

# Physical Examination

- Cranial drawer
- Tibial thrust
- What does instability mean?
  - Flexion only –
    Craniomedial band torn
  - Flexion & extension – Complete tear
  - None (?) – Caudolateral band torn
    * rare but possible

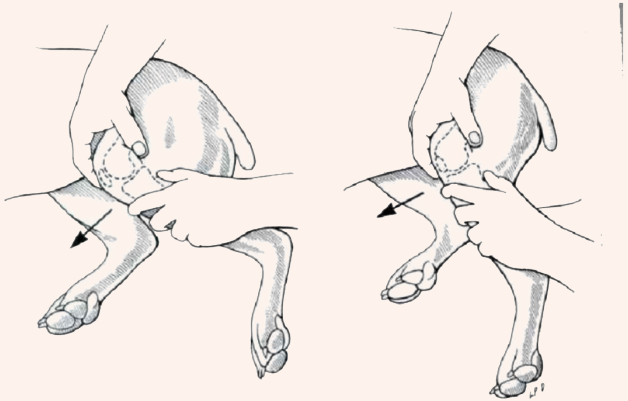

**Figure 147–12.** Tibial compression test. With the stifle joint in *slight* flexion, the hock is dorsiflexed, placing the gastrocnemius muscle under tension. If the cranial cruciate ligament is torn, the femur displaces caudally with simultaneous cranial subluxation of the tibia. The popping back and forth of the tibial tuberosity in association with hock motion is palpated with the index finger.

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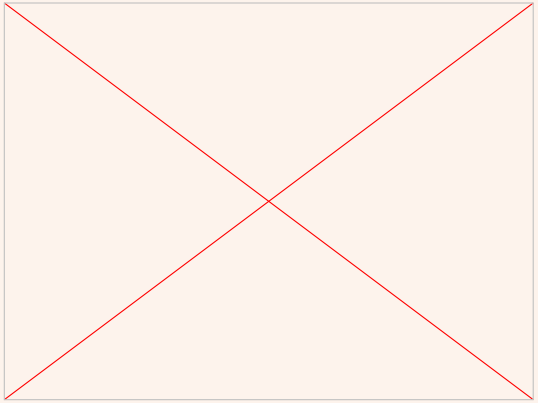

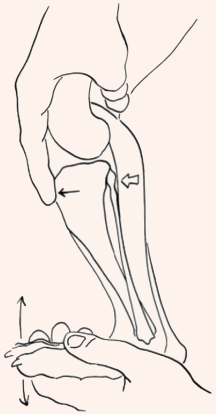

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# Diagnostics

- Radiographs
  - Increase suspicion of CCLR
    - Stifle effusion
    - Osteoarthritis
    - Drawer
  - Rule out unexpected findings
    - Fracture
    - Neoplasia


**FIGURE 61.17** A, Mediolateral radiographic image of a normal stifle joint from a 12-year-old Labrador Retriever. B and C, Mediolateral radiographic images of stifle joints with partial (B) and chronic, complete (C) cranial cruciate ligament rupture. D, Caudocranial radiographic image of the same stifle joint as shown in panel C, with chronic, complete cranial cruciate ligament rupture.

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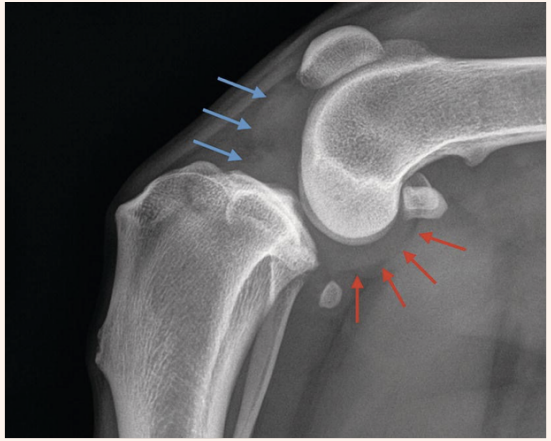
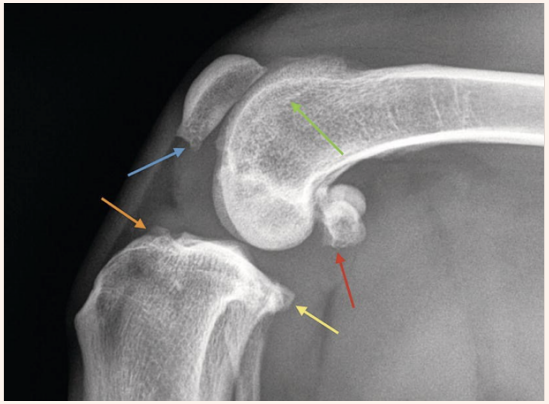
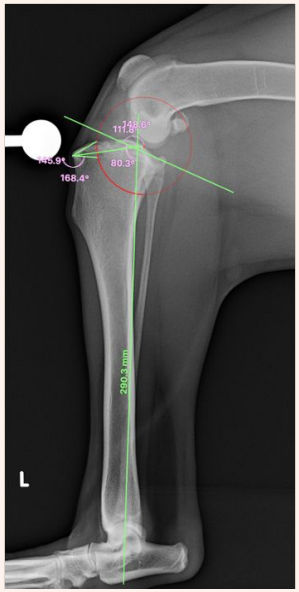




# Diagnostics

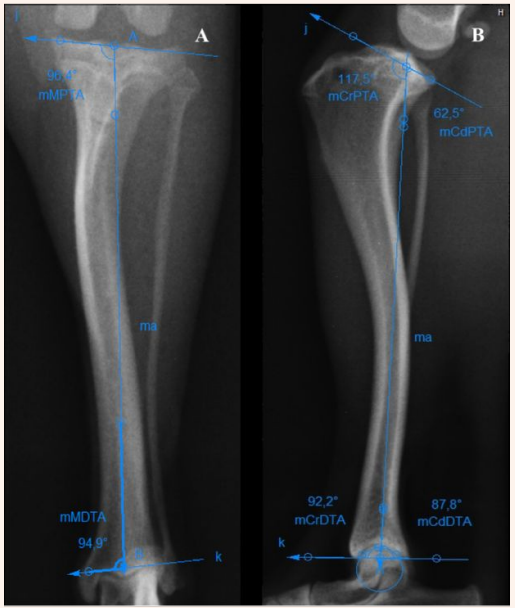
- Radiographs
  - Surgical planning
    - ALD

      . Varus/Valgus





Doberman




Maltese

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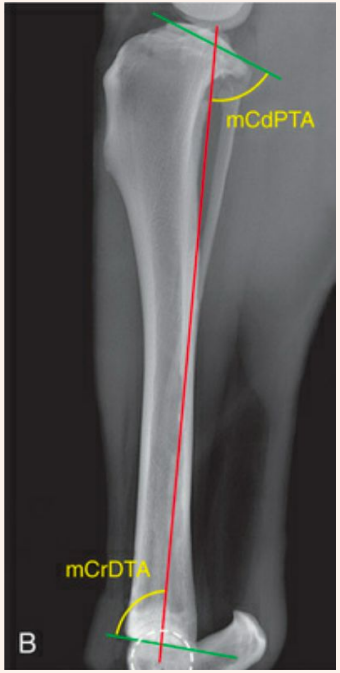
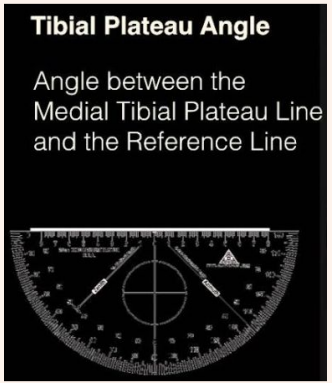
# Tibial Plateau Angle

- Angle formed between the slope of the medial tibial condyle and the line perpendicular to the mechanical axis of the tibia
    - “Normal” – 24-26°
        - Historical
        - Based on Labrador Retrievers
    - “New Normal” – 24.30-29°
        - Todorovic, VCOT 2022/Fox, VCOT 2020
        - Based on review of dogs w/ and w/oCCLR





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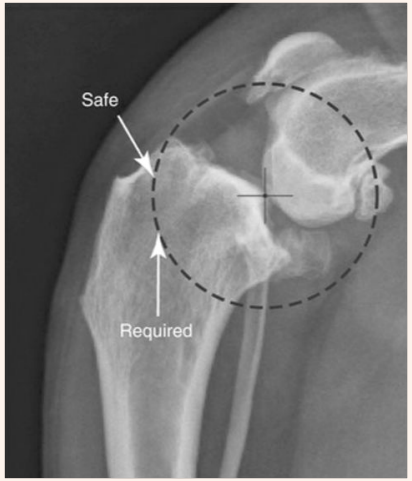
# Tibial Plateau Angle

- Importance of TPA
  - Increased TPA associated with increased risk of CCLR
    - Healthy 23.6° v Dogs w/ CCLR 25.5° (NS)
    - Some dogs with eTPA do not develop CCLR
  - Excessive TPA
    - Risk – increased risk of tibial tuberosity fracture
    - Definition
      - TPA > 34
      - OR rotation past the patellar tendon insertion
    - Risk factors associated with increased TPA
      - Neutered dogs
      - Breed (often small breed)




| Breed | Tibial Plateau Angle |
|---|---|
| Beagle | 32 |
| Bichon Frise | 34 |
| West-Highland Terrier | 35 |
| Yorkshire Terrier | 34 |

# Diagnostics

- Radiography HOW TO
  - Calibration
    - Always include calibration tool tuberosity fracture
    - Place at the level of the stifle
  - Center the beam
    - Mispositioning beam - 3.61°
    - Internal/external rotation - 1.6°

# Diagnostics

- Radiography HOW TO
  - Positioning
    - Craniocaudal
      - Intercondylar notch
      - Fabellae bisected by femoral cortex
    - Mediolateral
      - Superimposition of femoral condyles
      - Superimposition of tibial plateau condyles
      - Tarsus and Femur @ 90°



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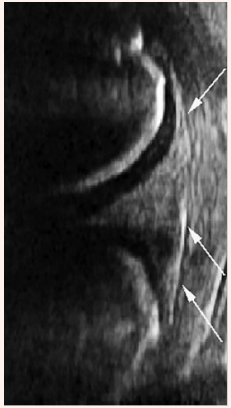
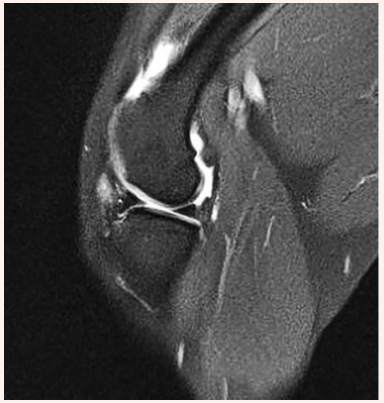
# Diagnostics

- Radiography HOW TO
  - Consider Stress radiographs = Tibial compression radiographs
    - Performance of tibial thrust in mediolateral radiographs
    - 98% accurate for diagnosis of CCLR

# Diagnostics

- Ultrasound
  - Used to diagnose meniscal injury
  - 90% sensitive, 92.9% specific
- CT scan
  - Best for evaluation of ALD
- MRI
  - Good for evaluation of stifle pathology
  - Accuracy
    - Detection CCLR - 68-71%
    - Detection of meniscal injury - <31%





Normal meniscus


Full-thickness tear

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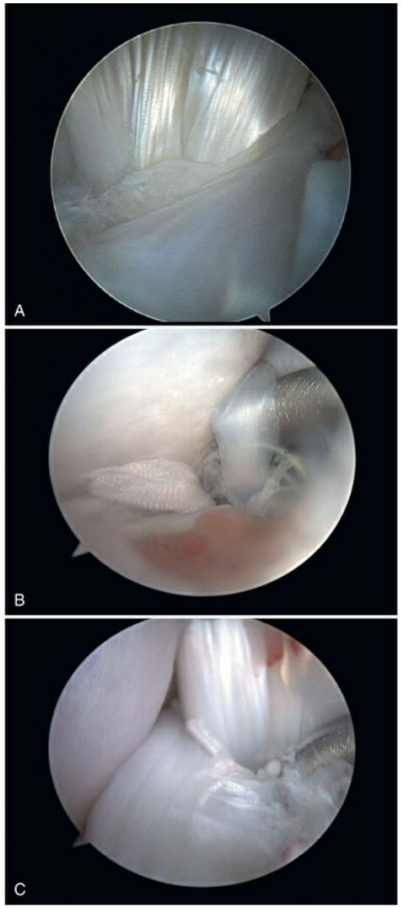
# Diagnostics

- Arthroscopy
    - Gold standard for joint evaluation (i.e. CCLR diagnosis, meniscal injury)
        - Early partial tearing – normal fiber pattern is lost (appears homogeneous, edematous, lax)
        - Synovitis
        - Cartilage fibrillation or eburnation
        - Osteophytosis



# Treatment

- Conservative management – 8-12 weeks crate rest
  - Indications
    - <20lbs
    - Often miniature breed
    - Poor anesthetic candidate
    - Patient is minimally lame at evaluation
  - Contraindications
    - Suspect meniscal injury
    - Severe lameness
    - Concurrent clinical MPL


When your patient is in shock and the owners want to try acupuncture.

# Treatment

- Custom knee orthotic
  - Indications
    - Patients unable to undergo anesthesia
  - Reasons why owner's elect to pursue
    - Concerns about surgery
    - Cost
    - Convenience
    - Personal preference
    - Veterinarian recommendation (up to 19%)
  - Complications
    - 63% reluctant to wear the device or did not wear the device due to fit or wounds
    - 46% developed skin issues
    - 11% later underwent surgical stabilization
  - Outcome
    - 85% would pursue a stifle orthotic again

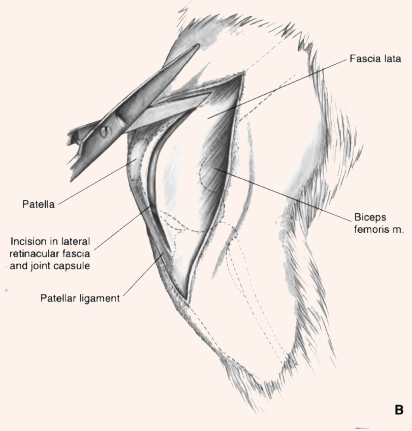
Image: Animal Ortho Care

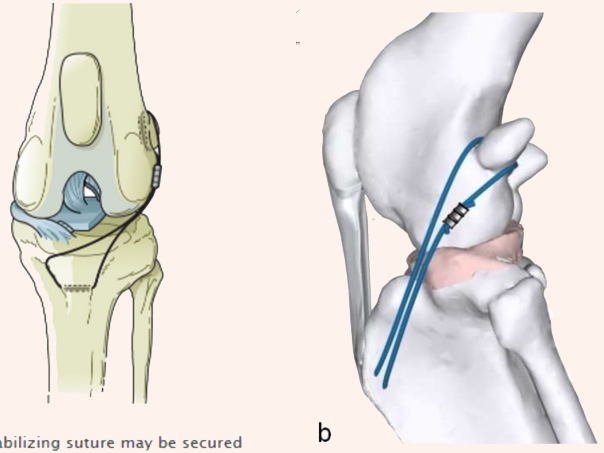
# Stabilization Techniques

- Extracapsular stabilization
  - = Lateral fabellar suture technique
    = Fishing line technique
  - Indications
    - <20lbs
    - Miniature breeds
      - with suspect meniscal injury
      - With concurrent clinical MPL
  - Contraindications
    - Nylon leader line (superior to others)
    - Strength of line (pound test) ≧ BW
      - E.g. 20lb patient ≧ 20lb leader line

# Stabilization Techniques

- Extracapsular stabilization
  - Stability achieved via periarticular fibrosis
  - Technique
    - Lateral stifle arthrotomy and examination
    - Reflect lateral fascia
    - Suture passed
      - Around fibrous origin of the lateral fabella
      - Underneath patellar tendon
      - Through tibial crest
    - Suture secured (knot v crimp)
      - ~100 flexion
      - Eliminate cranial drawer
      - Maintain stifle ROM




The stabilizing suture may be secured with a special clip rather than with a bulky knot.

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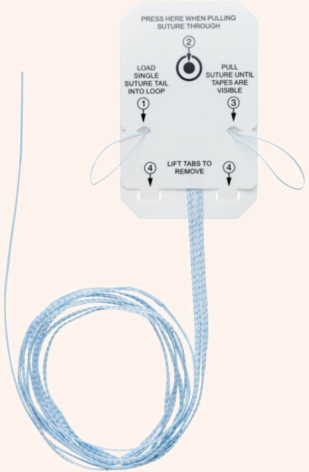
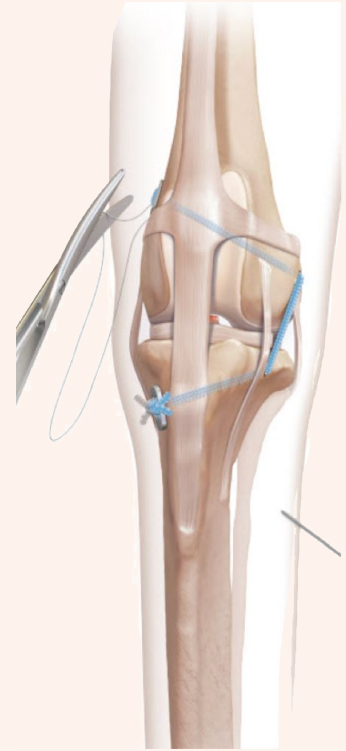
# Stabilization Techniques

- Extracapsular stabilization
    - Location of implant
        - Goal - isometry
            - 2 points that remain equidistant during stifle ROM
            - True isometry does not exist
        - F2 and T3 were closest (quasi-isometric)

# Stabilization Techniques

- Extracapsular stabilization
    - Similar procedures
        - TightRope CCL technique (Arthrex)
          - Secured using buttons
          - Uses FiberTape (UHMWPE)
        - SwiveLock (Arthrex)
          -Secured using bone anchors
          - Uses FiberTape (UHMWPE)



# Stabilization Techniques

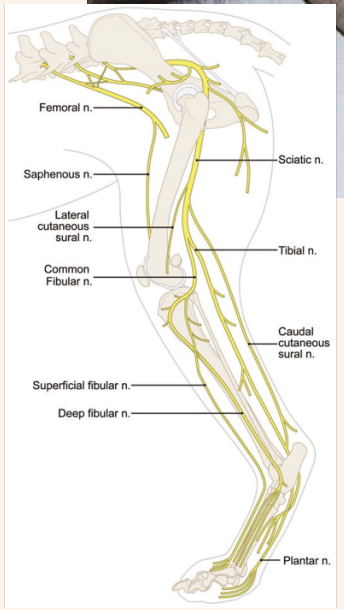
- Extracapsular stabilization
    - Postoperative recovery
        - surgery + 8-12 weeks rest
        - Increasing leash walks 2 weeks postoperative

# Stabilization Techniques

- Extracapsular stabilization
    - Outcome
        - In general limb function does improve significantly,
        - BUT return to normal is variable
        - Rehab result in significant improvement, up to normal
        - Outcome is not dependent on TPA

# Stabilization Techniques

- Extracapsular stabilization
    - Complications
        - Up to 17.4% of the time
            - SSI
            - Implant failure
            - Peroneal nerve deficits
        - Risk factors associated with complications
            - High body weight
            - Young age



# Stabilization Techniques

- Tibial Tuberosity Advancement
    - Advance patellar ligament to neutralize cranial tibial thrust force
    - Planning
        - Radiographs @ 135 degrees

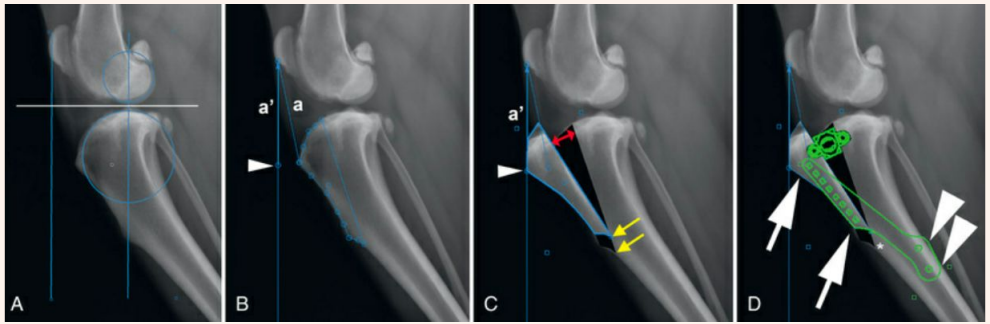
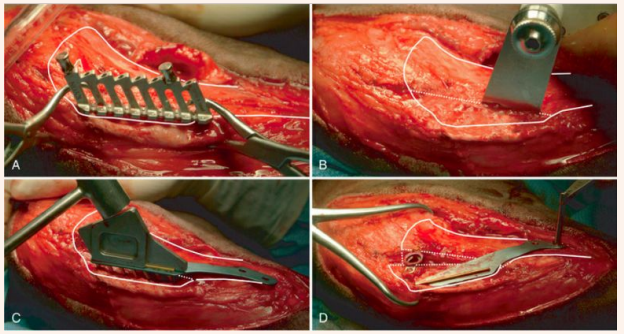


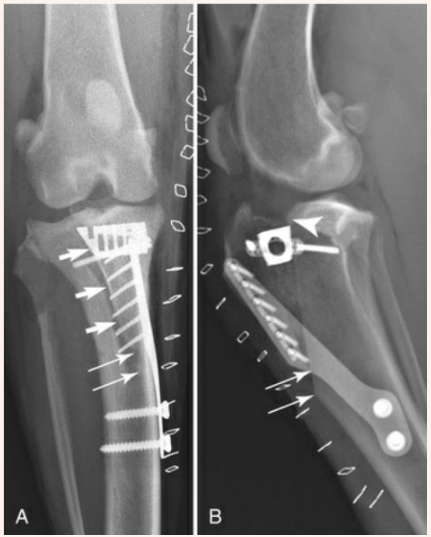


**FIGURE 1** Measurement of the patellar tendon angle with the conventional tibial plateau method. Line A corresponds to the tibial plateau (a line passing through both the origins of the cranial and caudal cruciate ligaments) and line B represents the cranial margin of the patellar ligament. The angle between these lines (PTA) is the patellar tendon angle

# Stabilization Techniques

- Tibial Tuberosity Advancement
    - Technique
        - Craniomedial approach
        - Arthrotomy
        - Drill for placement of plate
        - Osteotomy
        - Placement of cage and plate



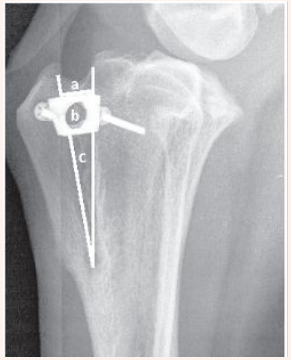



# Stabilization Techniques

- Tibial Tuberosity Advancement
    - Complications
        - Chronic lameness (chronic persistent instability)
        - Meniscal injury
        - Damage to LDE
        - SSI
        - Implant failure
        - Delayed union/nonunion
        - Tibial tuberosity fracture
        - Tibial fracture

# Stabilization Techniques

- Tibial Tuberosity Advancement
  - Advantages
    - Titanium Implant
    - Many variations
    - Less technically challenging osteotomy technique
  - Disadvantages
    - Increased complication rate
      - Up to 13.4% (particularly postliminal meniscal injury)
      - Cited by surgeons as a reason not to offer
    - Cannot address eTPA




Modified Maquet technique (Ramirez, 2015)

OrthoFoam MMP Wedge (user guide)


TTA rapid (Samoy, 2015)

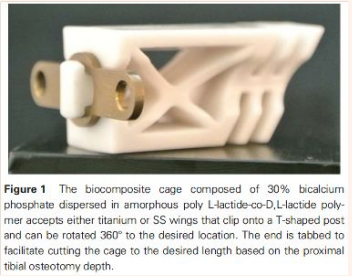


**Figure 1** The biocomposite cage composed of 30% bicalcium phosphate dispersed in amorphous poly L-lactide-co-D,L-lactide polymer accepts either titanium or SS wings that clip onto a T-shaped post and can be rotated 360° to the desired location. The end is tabbed to facilitate cutting the cage to the desired length based on the proximal tibial osteotomy depth.

Bioabsorbable biocomposite TTA cage (Barnhart, 2016)

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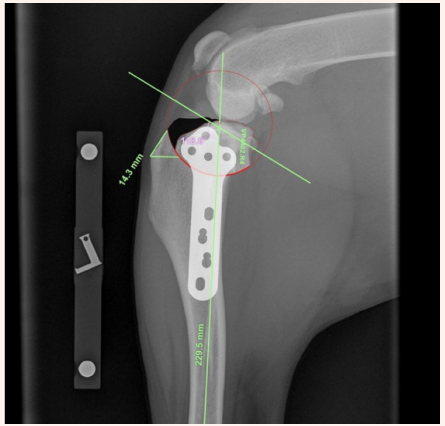
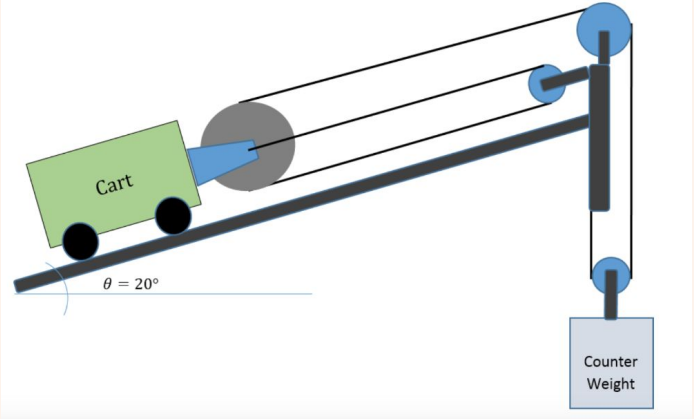
# Stabilization Techniques

- Tibial Plateau Levelling Osteotomy
    - Mechanism of action
        - Neutralize cranial tibial thrust
        - Recruit caudal cruciate ligament
    - Rotation of tibial plateau
        - Acceptable TPA 0-14 degrees
        - Ideal TPA 6.5 degrees

vPOP

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# Stabilization Technique

- Tibial Plateau Levelling Osteotomy
    - Technique
        1. Craniomedial incision
        2. Arthrotomy and joint explore
        3. Reflection of pes anserinus
        4. Measure D1, D2, D3 +/- blade radius
        5. +/- Placement of jig
        6. +/- Placement of radiopaque gauze caudal to tibia
        7. Rotation of proximal segment
        8. Placement of TPLO plate
        9. Check for
            1- Tibial thrust
            2. Excessive internal rotation


PREOPERATIVE TIBIAL PLATEAU ANGLE (TPA)

| Saw Radius | 15° | 16° | 17° | 18° | 19° | 20° | 21° | 22° | 23° | 24° | 25° | 26° | 27° | 28° | 29° | 30° | 31° | 32° | 33° | 34° | 35° | 36° | 37° | 38° | 39° | 40° |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Rotation (mm) — Provides Resultant 5° TPA | | | | | | | | | | | | | | | | | | | | | | | | | |
| 12 mm | 2.0 | 2.2 | 2.4 | 2.6 | 2.9 | 3.1 | 3.3 | 3.5 | 3.7 | 3.9 | 4.1 | 4.3 | 4.5 | 4.7 | 4.9 | 5.1 | 5.3 | 5.5 | 5.7 | 5.9 | 6.1 | 6.3 | 6.4 | 6.6 | 6.8 | 7.0 |
| 15 mm | 2.6 | 2.8 | 3.1 | 3.3 | 3.6 | 3.8 | 4.1 | 4.3 | 4.6 | 4.9 | 5.1 | 5.4 | 5.6 | 5.9 | 6.1 | 6.4 | 6.6 | 6.9 | 7.1 | 7.4 | 7.6 | 7.9 | 8.1 | 8.4 | 8.6 | 8.8 |
| 18 mm | 3.1 | 3.4 | 3.7 | 4.0 | 4.3 | 4.6 | 4.9 | 5.2 | 5.5 | 5.8 | 6.1 | 6.5 | 6.8 | 7.1 | 7.4 | 7.7 | 8.0 | 8.3 | 8.6 | 8.9 | 9.2 | 9.5 | 9.8 | 10.1 | 10.3 | 10.6 |
| 21 mm | 3.6 | 4.0 | 4.3 | 4.7 | 5.0 | 5.4 | 5.8 | 6.1 | 6.5 | 6.8 | 7.2 | 7.5 | 7.9 | 8.3 | 8.6 | 9.0 | 9.3 | 9.7 | 10.0 | 10.4 | 10.7 | 11.1 | 11.4 | 11.8 | 12.1 | 12.4 |
| 24 mm | 4.1 | 4.5 | 5.0 | 5.4 | 5.8 | 6.2 | 6.6 | 7.0 | 7.4 | 7.8 | 8.2 | 8.6 | 9.0 | 9.5 | 9.9 | 10.3 | 10.7 | 11.1 | 11.5 | 11.9 | 12.3 | 12.7 | 13.1 | 13.5 | 13.9 | 14.3 |
| 27 mm | 4.7 | 5.1 | 5.6 | 6.0 | 6.5 | 7.0 | 7.4 | 7.9 | 8.4 | 8.8 | 9.3 | 9.7 | 10.2 | 10.6 | 11.1 | 11.6 | 12.0 | 12.5 | 12.9 | 13.4 | 13.8 | 14.3 | 14.7 | 15.2 | 15.6 | 16.1 |
| 30 mm | 5.2 | 5.7 | 6.2 | 6.7 | 7.2 | 7.8 | 8.3 | 8.8 | 9.3 | 9.8 | 10.3 | 10.8 | 11.3 | 11.8 | 12.3 | 12.9 | 13.4 | 13.9 | 14.4 | 14.9 | 15.4 | 15.9 | 16.4 | 16.9 | 17.4 | 17.9 |

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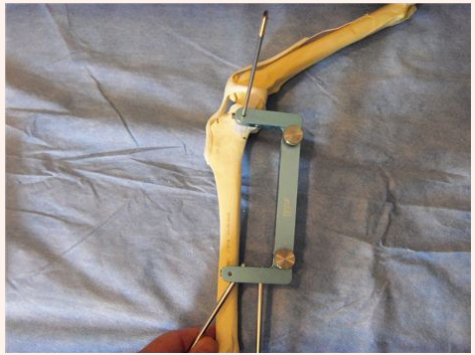
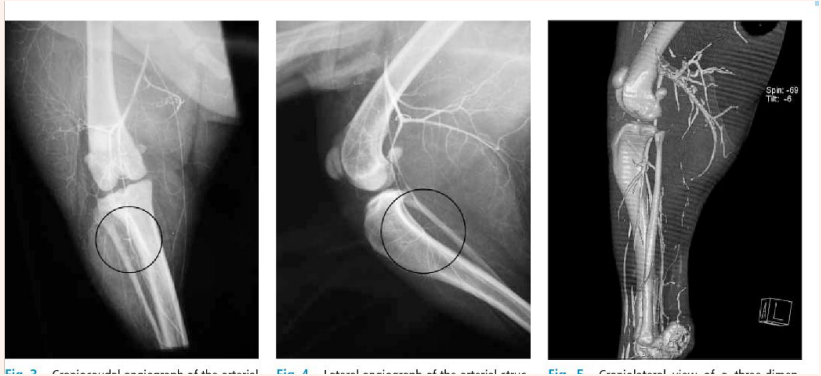
# Stabilization Techniques

- Tibial Plateau Levelling Osteotomy
    - TPLO osteotomy jig
        - Controversial
        - Risk
          - Intra-articular pin placement
          - Iatrogenic fracture
        - Benefit
          - Aid in osteotomy orientation
          - Stabilization of bone segments
          - Facilitate limb alignment
          - +/- placement of osteotomy



# Stabilization Techniques

- Tibial Plateau Levelling Osteotomy
    - Elevation of popliteal muscle/cranial tibial muscle with gauze
        - Goal
          - Prevention of cranial tibial artery bleeding
          - Protection of caudal tibial soft tissues
        - Risk
          - Gossypiboma
          - Retention of gauze debris



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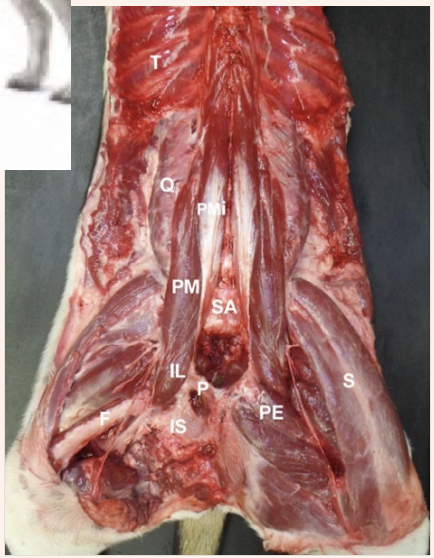
# Follow up

- 2 weeks postoperatively
    - Physical examination
        - Goal
            - Healed incision (E-collar removal)
            - Weight-bearing lameness
            - Comfortable with stifle ROM
            - Stifle stability
        - Note
            - Degree of muscle atrophy
            - Degree of stifle effusion
        - Rule out things requiring intervention
            - SSI
            - Rupture of the pes (feels like the plate is under the skin)
            - Severe stifle effusion (seroma)
            - Compensatory injury (e.g. iliopsoas strain)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# Follow up

- Timing
    - +/- 4 weeks postoperatively
        - Physical exam
          - Near resolution of lameness
        - Sedated radiographs
        - Instructions
          - Increase leash walks gradually
          - Continued exercise restriction
          - Consider PT

# Follow up

- Timing
  - 8 weeks postoperatively
    - Physical exam
      - Normal gait
    - Sedated radiographs
      - Bony osteosynthesis
    - Instructions
      - Increase leash walks gradually (to 30-45 min)
      - Gradual reduction in exercise restriction
      - Consider PT
  - +/- 12 weeks postoperatively
    - As needed
    - Use to address any issues following return to normal function

# Follow up

- Evaluation of postoperative radiographs
  - Evaluate
    - 4 A's of fracture management
      - Alignment (r/o angular deformity)
      - Apposition (fracture healing requires 50% apposition)
      - Activity (progression of bony osteosynthesis, r/o evidence of infection)
      - Apparatus (appropriate placement, r/o implant failure)
    - Joint
      - Resolution of joint effusion
    - Soft tissues
      - Evidence of soft tissues swelling (suggestive of infection)
    - TPA

# Follow up

- Evaluation of postoperative radiographs
  - Rule out
    - Rockback
    - Patellar desmopathy
      - Thickening (radiographically visible)
      - Tendinosis (pain)
        - Pain on palpation of patellar tendon/insertion on tibial tuberosity
        - Risk factor - partial CCLR
      - Physical therapy
    - Stifle effusion
      - Refer if clinical

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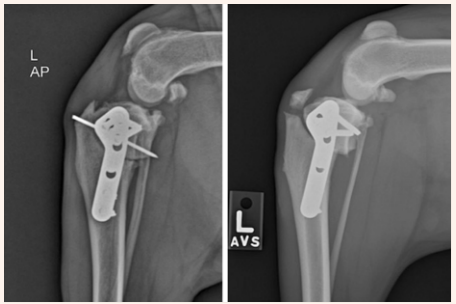
# Follow up

- Evaluation of postoperative radiographs
  - Rule out
    - Tibial tuberosity fracture (4.2%)
      - Risk factors
        - Cranial osteotomy
        - Distal rotation of the proximal segment
        - Proximal placement antirotational k-wire
      - Prevention
        - Use the TPLO jig
        - For dogs at risk (dogs with eTPA)
          - Combine with Cranial Wedge Osteotomy
          - Instead perform Cranial Wedge Osteotomy
      - Refer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# Follow up

- Evaluation of postoperative radiographs
    - Rule out
        - Fibular fracture
            - Risk factors
                - Increasing body weight
                - Increased TPA
                - Greater change TPA
                - TPLO performed without a jig
                - Secondary to lateral cortical collapse
            - Manage Conservatively

# Follow up

- Evaluation of postoperative radiographs
    - Rule out
        - Implant failure
          - Increased risk with lack of compression
          - Refer
        - Nonunion/malunion
          - Increased risk with lack of compression
          - Refer


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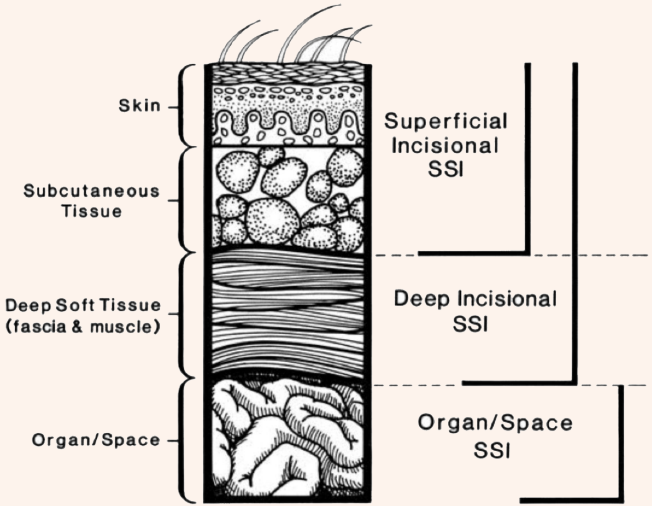
# Follow up

- Evaluation of postoperative radiographs
  - Rule out
    - Surgical site infection
      - Reported in 3-15.8% dogs
        *This is a clean procedure, SSI should be <5%
      - Anytime postoperatively
        ** Note: According to the CDC
        . Superficial SSI - within 30 days
        . Deep SSI - within 90 days
      - Treatment most commonly = implant removal

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# Follow up

- Evaluation of postoperative radiographs
    - Rule out
        - Surgical site infection

- Risk factors
    - GSD (OR 7.4x)
    - Male (OR 1.8x)
    - +/- Increased weight
    - Preoperative colonization with MRSP
    - Anesthesia time
    - Performance of meniscectomy
    - Non-locking implants in dogs >50kg
    - +/- Lack of postoperative antibiotics


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# Complications

- Meniscal tear
    - Latent – present at initial procedure but not identified
    - Postliminary – occur after initial procedure
    - Incidence:
        - 2.8 - 27.8%
        - Often < 6 months postoperative
    - Risk factors
        - Intact menisci @ time of initial procedures v release/partial meniscectomy.
        - TTA v other
          - Up to 3x > TPLO
          - Up to 6x > TightRope

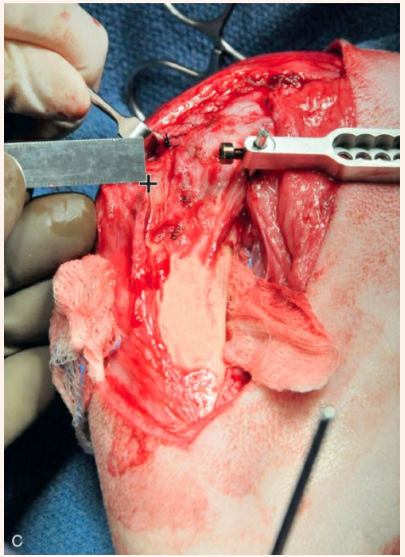
# Complications

- Pivot shift
  - Poorly described
  - Proposed contributing factors
    - Conformation (including genu varus)
      - Can be addressed at surgery
        - Rotation proximal segment TPLO
        - Augmentation with lateral suture
    - Secondary stifle stabilizers (e.g muscles /ligaments)
      - Can be addressed with physical therapy (development of hamstring muscles)
    - Complete v partial rupture CCLR
    - Meniscectomy v intact meniscus

# Complications

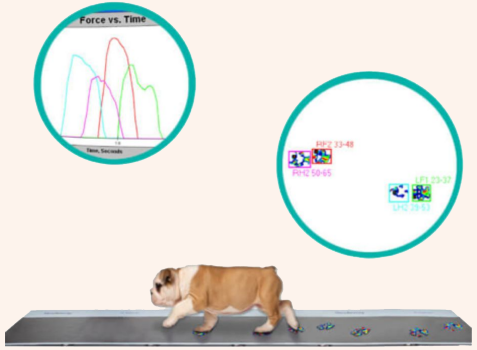
- Gossypiboma
  - Original description of procedure includes packing caudal tibia with gauze
  - Always use radiopaque gauze

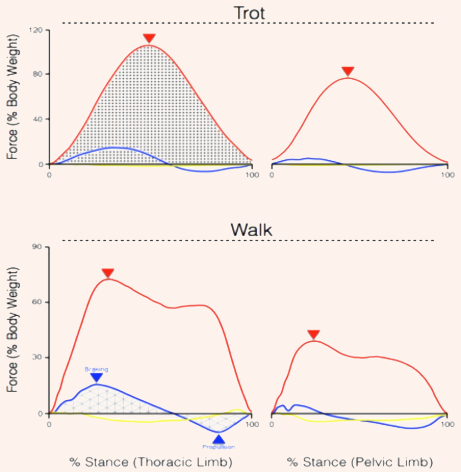

**Figure 1**—Mediolateral (A) and craniocaudal (B) radiographic views of the right stifle joint of a 5-year-old 43.0-kg (94.6-lb) castrated male Rottweiler that was evaluated for a 5-month history of 2 draining tracts following tibial plateau leveling osteotomy and subsequent implant removal and antimicrobial treatment.



# Outcome

- Goals
  - Address cranial tibial subluxation and internal tibial rotation
  - Slow progression of OA
  - Mitigate likelihood of post-operative meniscal damage
- Stifle  kinematics in dogs with CRCL
  - Cranial tibial subluxation - ~10mm
    - Intact CrCL - 1.6mm
  - Stifle flexion increased 8-20 degrees
  - Greater internal tibial rotation in vitro (not replicated in-vivo)

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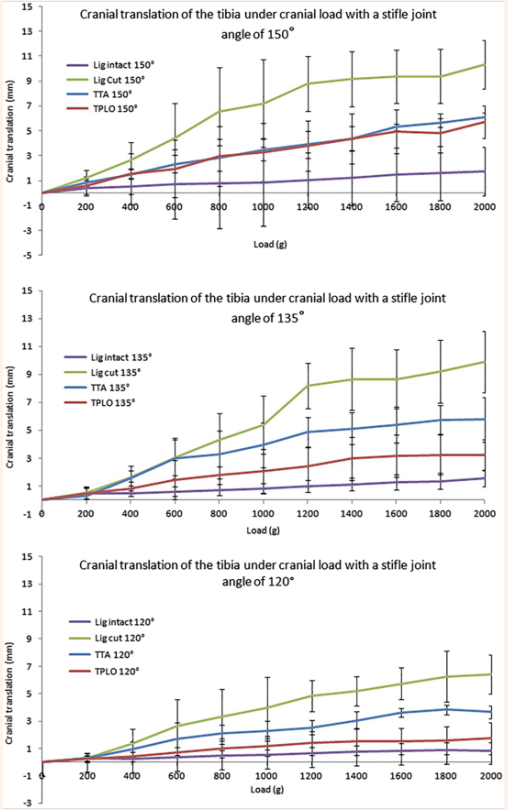
# Outcome - Comparison

| | LFS | TTA | TPLO |
|---|---|---|---|
| **Owner satisfaction** | 75% | 84-92% | 93% |
| **Surgeon Preference** | | | |
| ·Dogs <15kg | 63% | 32.9% | 32.9% |
| ·Dogs >15kg | 24.6% | 13.9% | 78.6% |
| **Osteoarthritis** | Worse than TPLO | Worse than TPLO | Progressed |
| **Kinematics** | | | |
| ·Limb use, subjective | Normal | Normal | Normal |
| ·Limb use, objective | Abnormal | Improved | Normal |
| ·Cranial tibial subluxation | Persistent 100% patients | Controversial (weight-bearing analyses conflict) | Reduced by 40% or more |
| ·Internal tibial rotation | Absent | | Linked to abnormal subluxation |

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# Outcome - Comparison

- Summary
  - None results in return to normal stifle kinematics
  - TPLO is closest
    - Less OA progression
    - Maximum improvement in persistent stifle instability
    - Is preferred by 80% surgeons in dogs >15kg
  - Persistent stifle instability is not benign
    - OA progression
    - Postliminary meniscal injury

# Alternative Stabilization Techniques

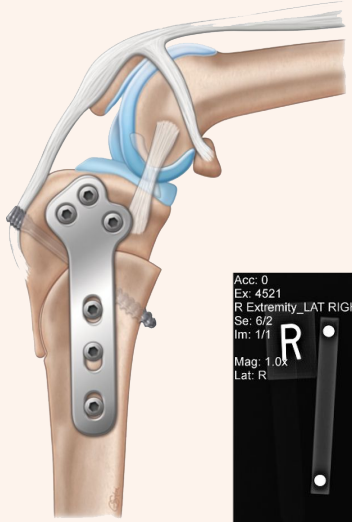
- Intra-articular stabilization
    - Materials
        - Allograft – graft from donor of same species, not genetically identical
        - Autograft – graft from separate site, same individual
          - Patellar, Semitendinosus, Gracilis, Quadriceps femoris tendon
        - Xenograft – graft from donor of different species (bovine)
          - Not typically successful (intense inflammatory/immune response)
        - Synthetic
    - Incorporation requires ~ 20 weeks
    - Ligamentization – inflammation caused by fibroblast necrosis à fibroblast re-infiltration, collagen secretion, revascularization

# Alternative Stabilization Techniques

- Intra-articular stabilization
  - Complications
    - 80-90% good to excellent results
    - Recent literature suggests that failure and complication rate make this procedure inadvisable
      - Up to 52% major complications (septic joint, implant failure, reaction, recurrent lameness)
      - Bernhart VCOT 2016
    - 55% implant failure by 20 months (found that intact grafts more likely to have successful outcome than torn)
      - Biskup VS 2020

# Alternative Stabilization Techniques

- CORA-based levelling osteotomy
  - Osteotomy based on the tibial CORA
  - Aim is for postoperative TPA 10-12 degrees
  - Advantages
    - Avoids physis in growing dogs
    - Minimizes articular damage
  - Main disadvantages
    - Rockback (addressed using headless compression screw)
    - Angular deformities due to engagement of the physis
      - Varus
      - Recurvatum

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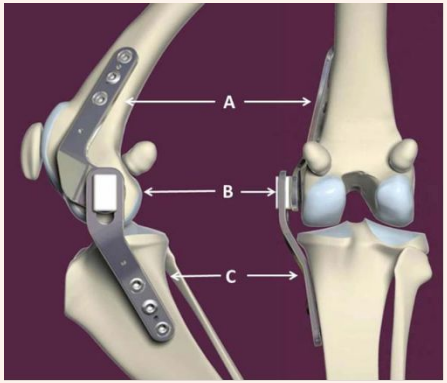
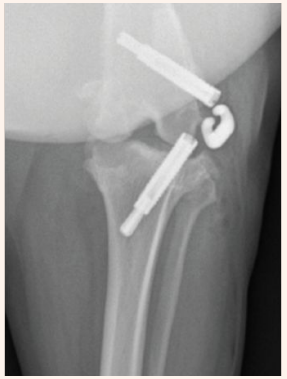
# Alternative Stabilization Techniques

- Simitri Stable in Strifle extracapsular articulating implant
    - Advantages- immediate stability, increased ROM
    - Evidence - 15.3% complications in 60 dogs
- Extracapsular bone anchor Ruby system
    - Advantages - immediate stability
    - Evidence - 12% complications in 17 dogs

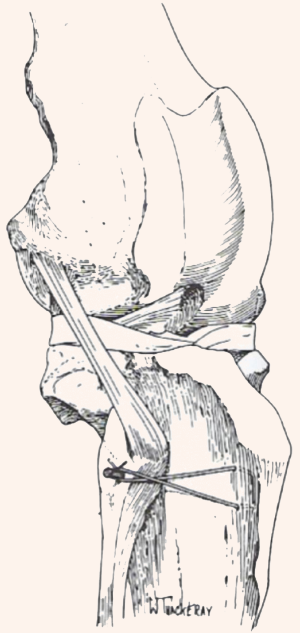






# Alternative Stabilization Techniques

- Outdated procedures
    - Fibular head transposition
        - 0% return to normal via kinematic gait analysis
        - Significant persistent instability
        - 50% dogs postliminary meniscal injury within 10 months postoperative



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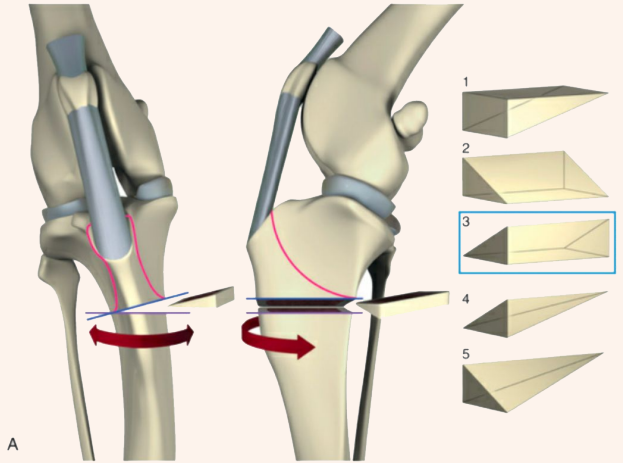
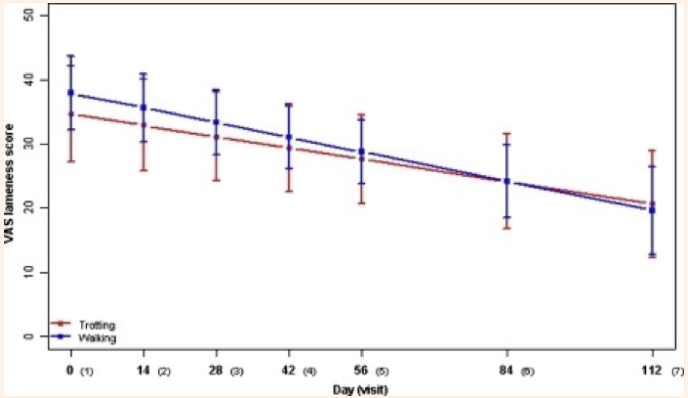
# Alternative Stabilization Techniques

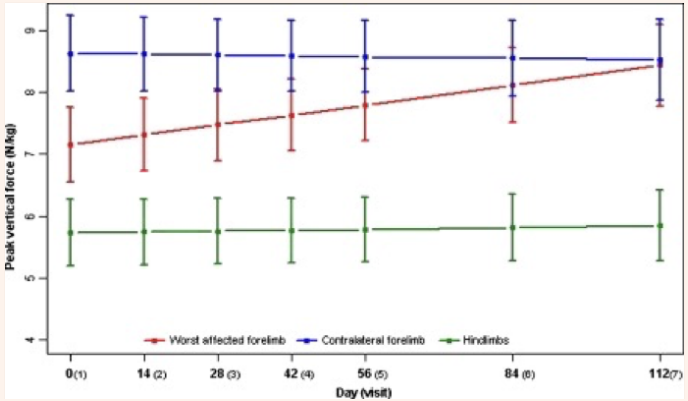
- Outdated procedure
  - Cranial tibial closing wedge osteotomy
    - Can be used alone for patients with visible physis
    - Out of favor when performed alone
      - Inconsistency in the postoperative TPA
      - Hyperextension of the stifle/patella baja
      - CBLO can also be used in dogs with visible physis
    - Commonly used in combination with TPLO
      - Patients with excessive TPA
        - Decreased risk of complications
        - Decreased soft tissue restrictions
      - Treat dogs with proximal tibial deformity



# Osteoarthritis management

- Management is multimodal
    - Weight loss
        - Overweight/obesity is linked to
            - Risk of OA
            - Severity of OA
            - Acceleration in need for OA treatment
            - Severity of clinical signs
            - Acceleration in euthanasia

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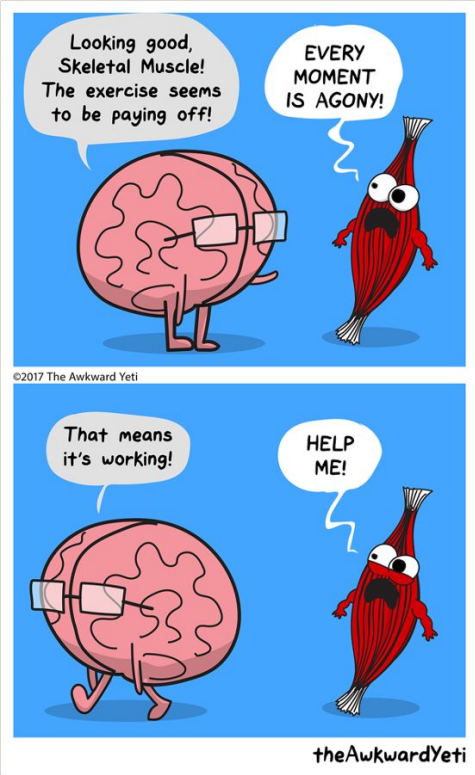
# Osteoarthritis management

- Moderate exercise
    - Increase in objective limb use
- Physical Therapy
    - Up to 46% of owners did not pursue physical therapy because they were not told it was needed
    - Associated with increased PVF over time
    - Associated with less progression of OA

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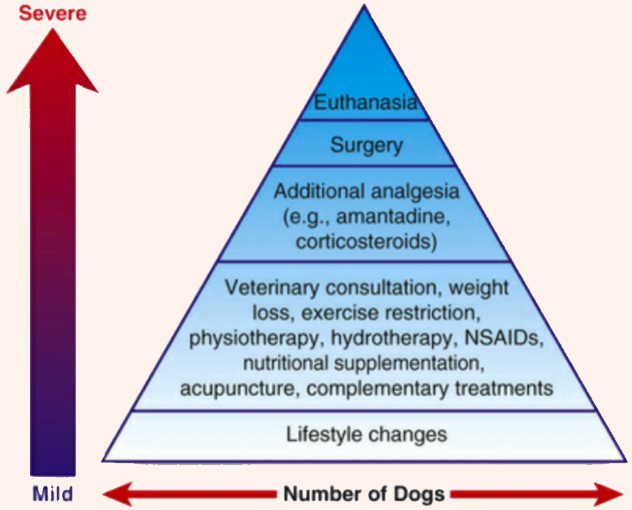
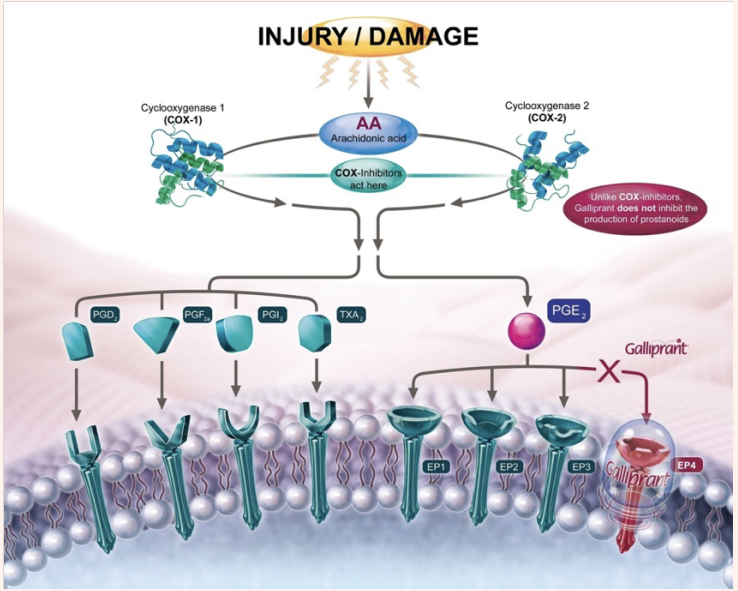
# Osteoarthritis management

- Joint supplements
    - Polysulfated glycosaminoglycans (Adequan)
    - Pentosan polysulfate (Cartophen)
    - Omega-3-FA
    - Collagen-containing nutraceuticals (Movoflex)
    - Glucosamine-containing nutraceuticals (Dasuquin)



# Osteoarthritis management

- Symptom modifying medication
    - NSAIDs
    - EP4 inhibitors (Galliprant)
    - Amantadine
    - Gabapentin
    - Acetaminophen (DOG ONLY)
    - Opioids
    - Corticosteroids
- Stem cell therapy
- Radiation Therapy

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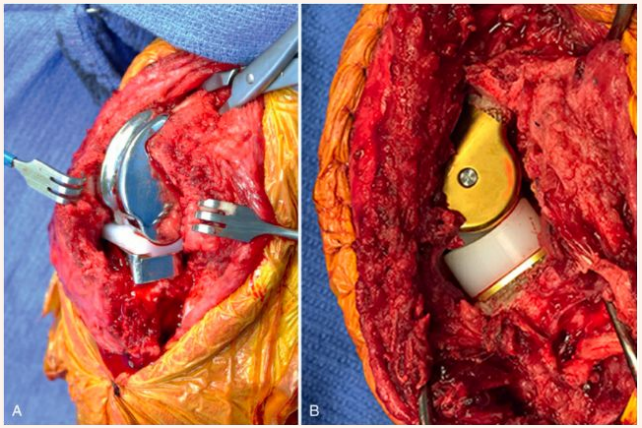
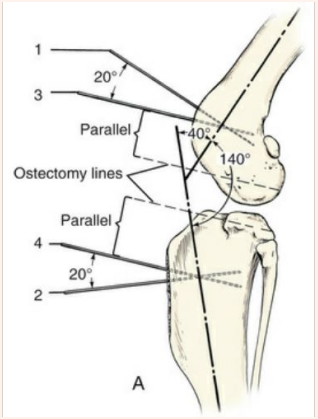
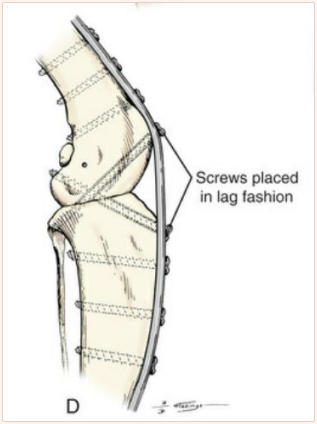
# Salvage Options

- Amputation
- Total knee replacement
    - Prognosis: good (additional information needed)
- Stifle arthrodesis
    - Prognosis: fair to good
- Euthanasia




# The End

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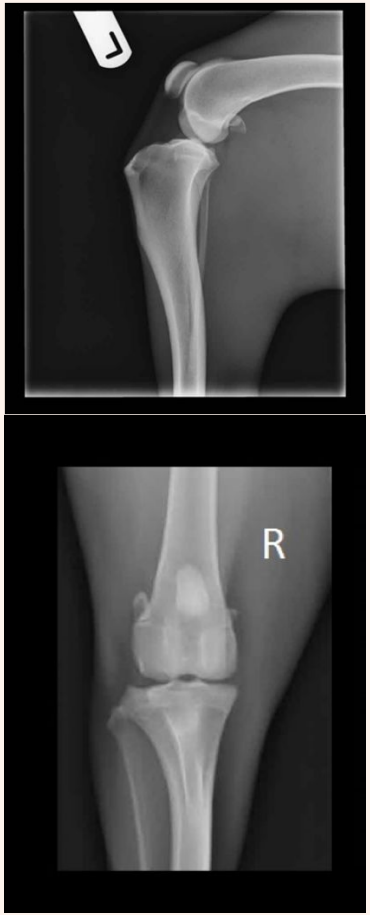
# Anatomy of the Stifle

- Bones
    - Femur
    - Tibia
- Long Bones
    - Patella - insertion of the patellar tendon
    - Fabella - origin of the gastrocnemius muscles
    - Popliteal - origin of the popliteus



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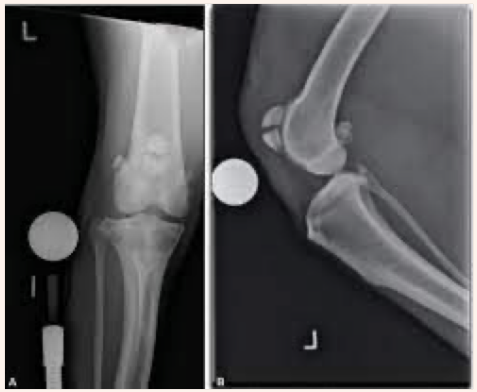

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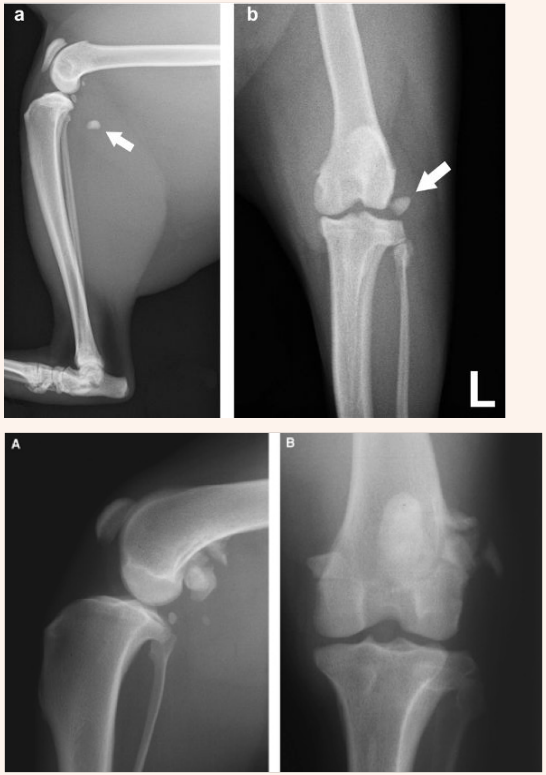
    - Fabella - origin of the gastrocnemius muscles
    - Popliteal - origin of the popliteus

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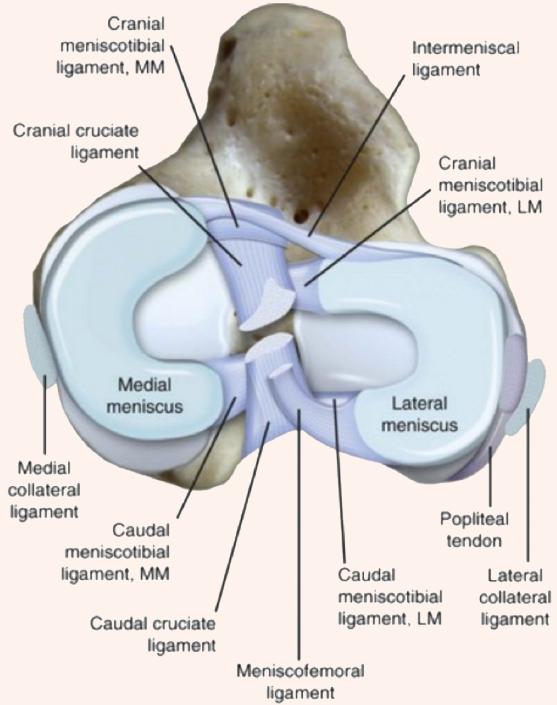
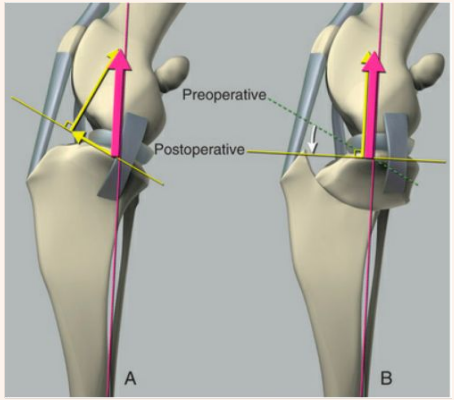
- Ligaments
  - Meniscotibial ligaments (x4)
    - Cranial/Caudal meniscotibial ligaments for Medial/Lateral menisci
  - Femoral ligament
    - Runs from lateral meniscus to femur

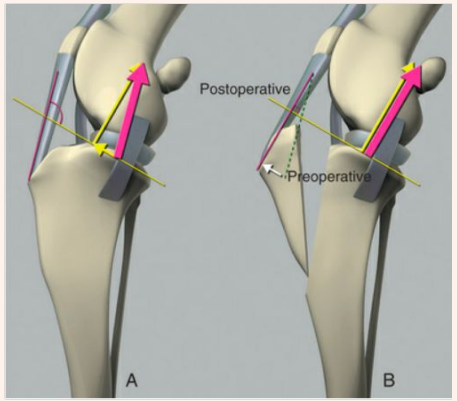


- Ligaments
    - Lateral/Medial collateral ligaments
    - Patellar ligament
    - Femoropatellar ligaments

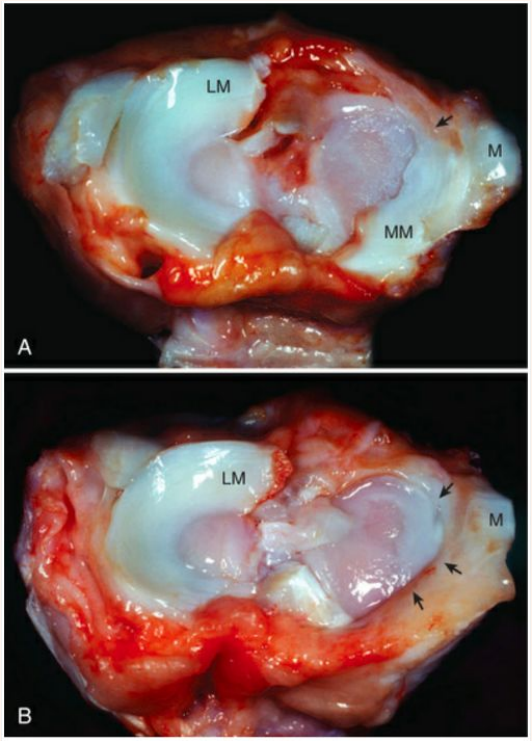
# Models of stifle joint instability

- Slocum and Slocum Model (1993)
  - Cranial tibial thrust = tibial slope + joint reaction force
    - Joint reaction force = parallel to functional axis of the tibia
  - Levelling tibia plateau reduces cranial tibial thrust
- Tepic Model (2002)
  - Cranial tibial thrust = shear force + joint reaction force
    - Joint reaction force = parallel to patellar tendon
  - Levelling tibia plateau so perpendicular to Patellar ligament



# Why is the medial meniscus so susceptible ?

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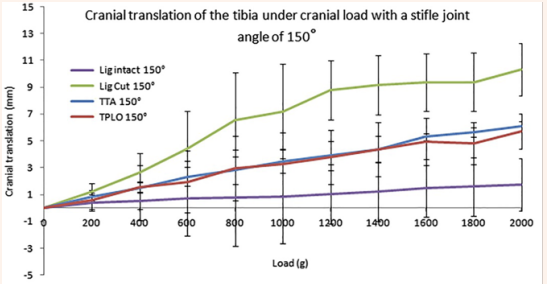
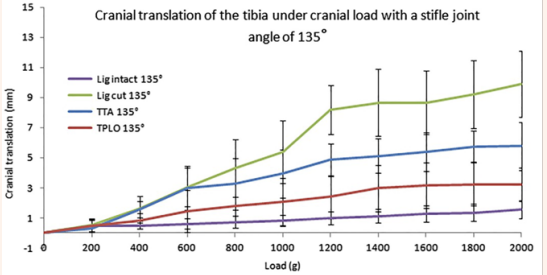
# Outcome

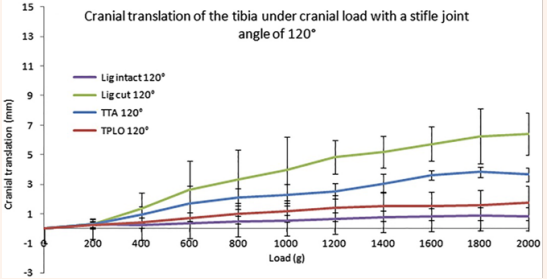
- Lateral suture v TPLO
    - 102 - Conzemius et al JAVMA 2005
        - No significant difference in limb use between TPLO and lateral suture
    - OA expected, but significantly more likely with LFS
- TPLO
    - 34 - Ballagas et al Vet Surg 2004 (TPLO)
        - No significant difference in limb use from baseline
    - 293 - unilateral TPLO
        - Thigh circumference 98.5% normal, smaller ROM
    - 2 look arthroscopy reveals no change in partial tears 9no mention of OA)

# Outcome

- TPLO v TTA
  - Persistent instability
    - Both TPLO and TTA reduced tibial thrust (cranial translation)
    - TPLO results in same cranial translation as Intact joint
  - OA progressed more after TTA than TPLO
  - Owners note reduced pain and fewer mobility issues after TPLO v TTA

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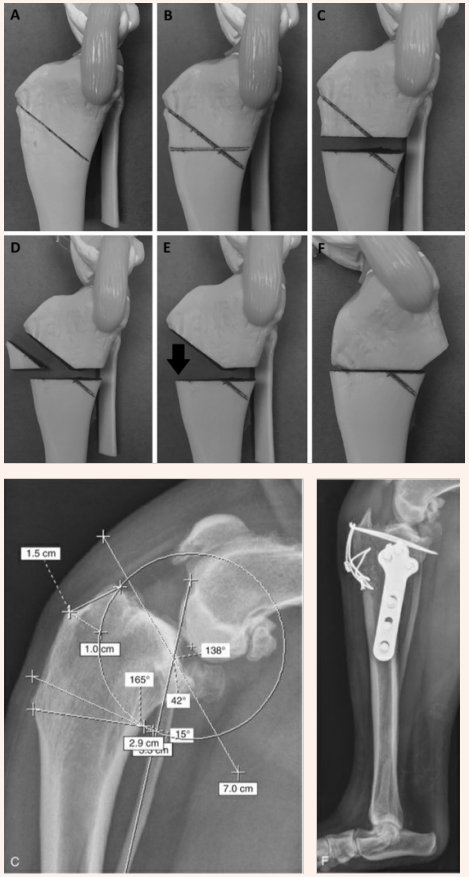
# Complications

- Fractures
  - Fracture of the tibial tuberosity
    - Cause – rotation of the plateau segment Beyond insertion of the patellar tendon
    - Prevention
      - Use the TPLO jig
      - For dogs at risk (dogs with eTPA)
        - Combine with Cranial Wedge Osteotomy
        - Instead perform Cranial Wedge Osteotomy



# Meniscus

- Fibrocartilage
- Blood supply
  - Vascular aspect of synovium
    *all offshoots of femoral a
  - Zones
    . Red-Red: Outer 15-20%, vascular supply
    . Red-White: Small intermediate portion, reduced supply
    . White-White: 80-85%, avascular
- Functions
  - Improve joint congruity
  - Load distribution
  - Shock absorption