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Introduction to the Invetra Pedicle Screw System

and its use in L7-S1 and Thoracolumbar stabilizations

Innovations in Veterinary Neurological Care

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Introduction to the Invetra Pedicle Screw System and its Use in L7-S1 and Thoracolumbar stabilizations

Contents

Labs

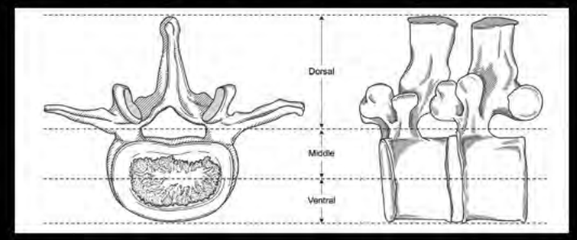
Introduction

INTRODUCTION

- Pedicle screw fixation has become standard practice in treatment of many human spinal disorders
- Pedicle screw fixation (PSF) is an implant placed from a dorsal approach into pedicle of a vertebrae
  - Interconnected with rigid rods in longitudinal direction

Introduction: Pedicle Screw Systems

- Provide rigidity and correct spinal alignment
- Benefits
  - Immediate stability of unstable vertebral motion segment
  - Rigid immobilization to promote fusion
  - Relatively short segment of vertebral column fixation
- Short segment of fixation limits need for long spans and subsequent loss of mobility
- Proper placement of screws results in rigid fixation of 3 spinal columns



Shores A. Spinal Trauma *Vet Clin* 1992

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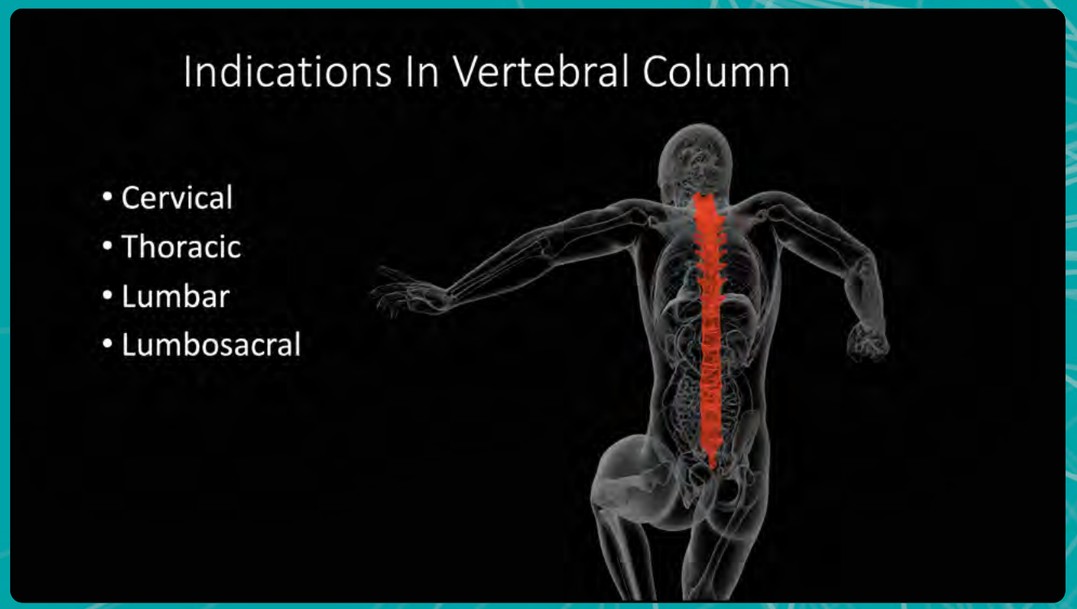
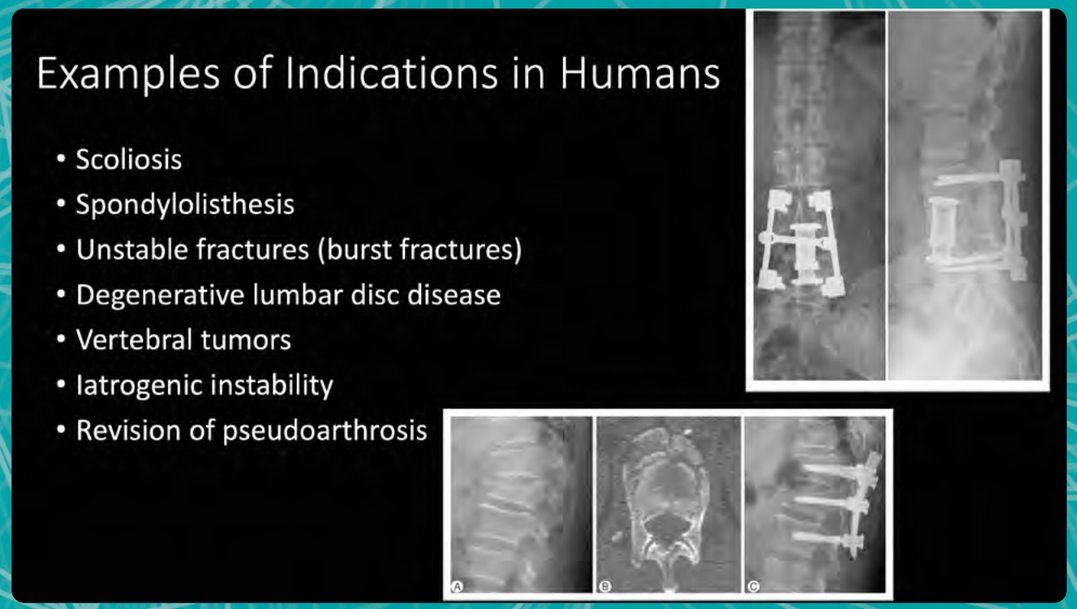
Indications in Vertebral Column





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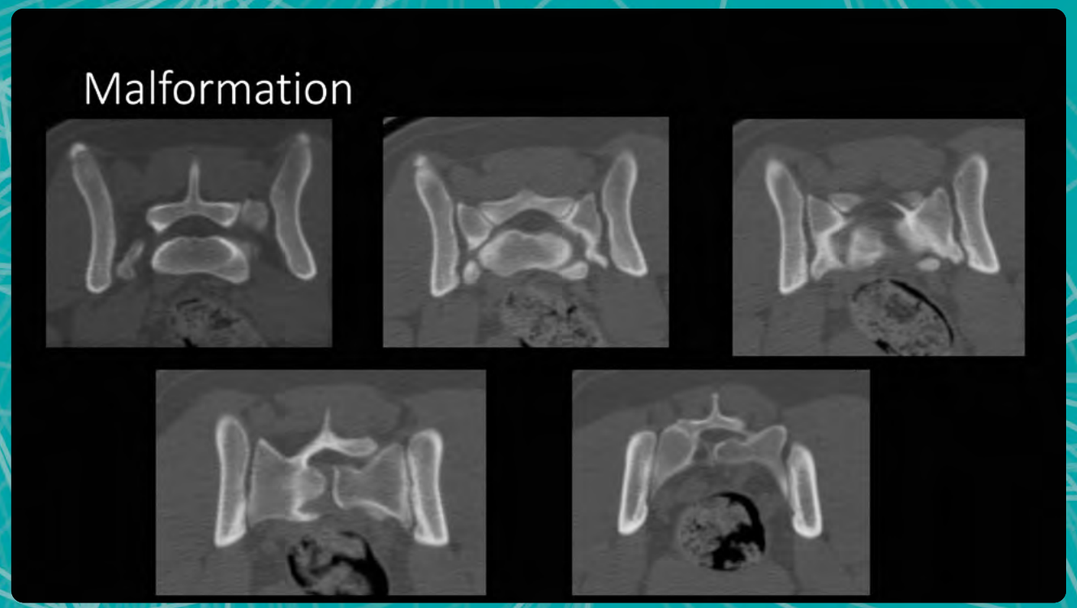

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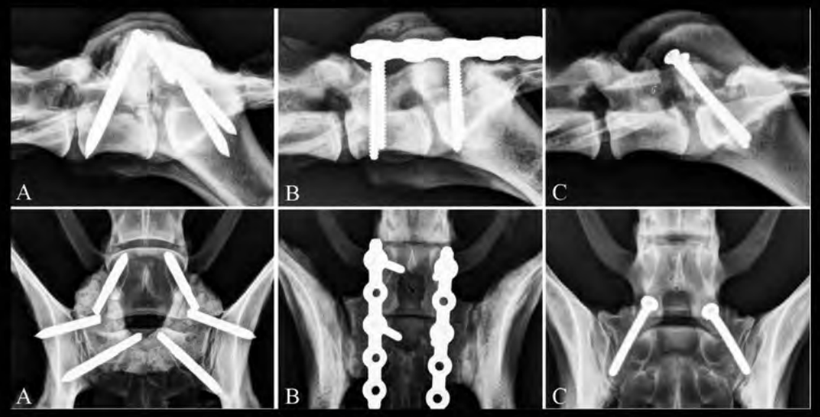
How Do We Stabilize LS in Dogs?



Early et al. Peer J 2015.

Malformation

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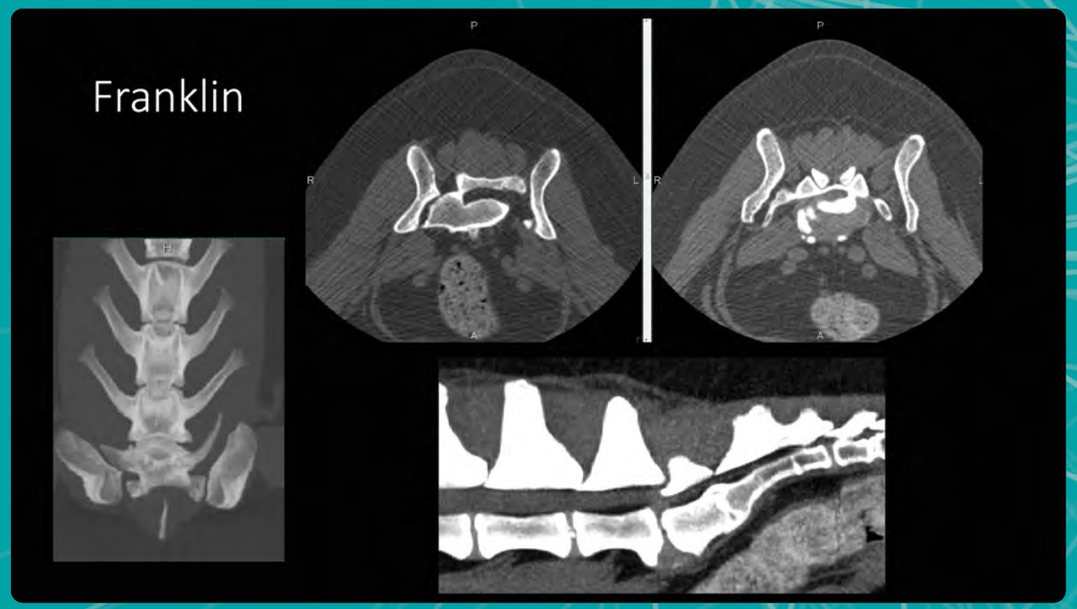

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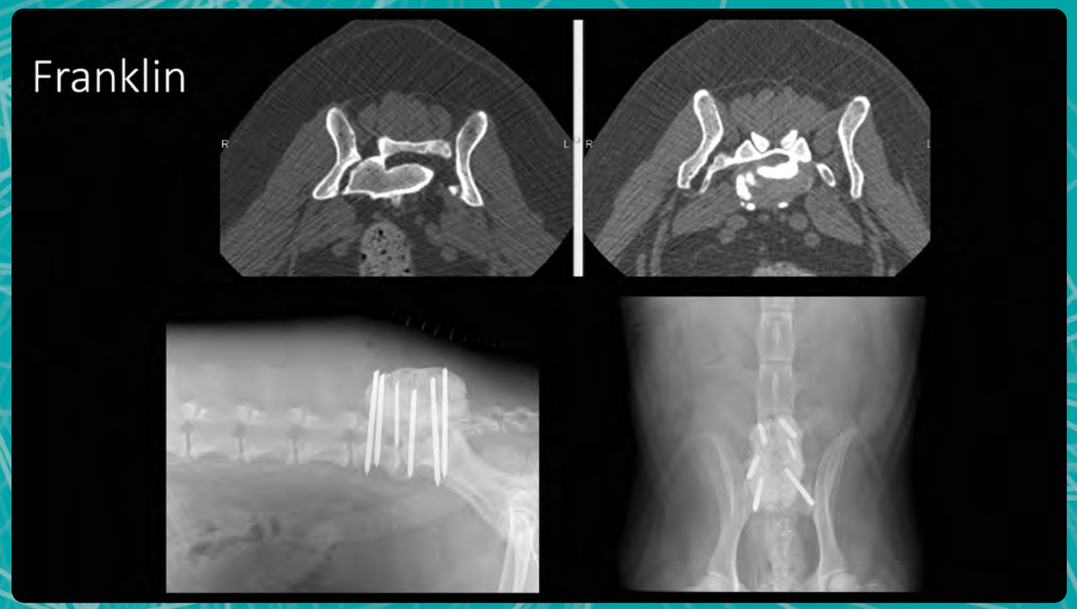

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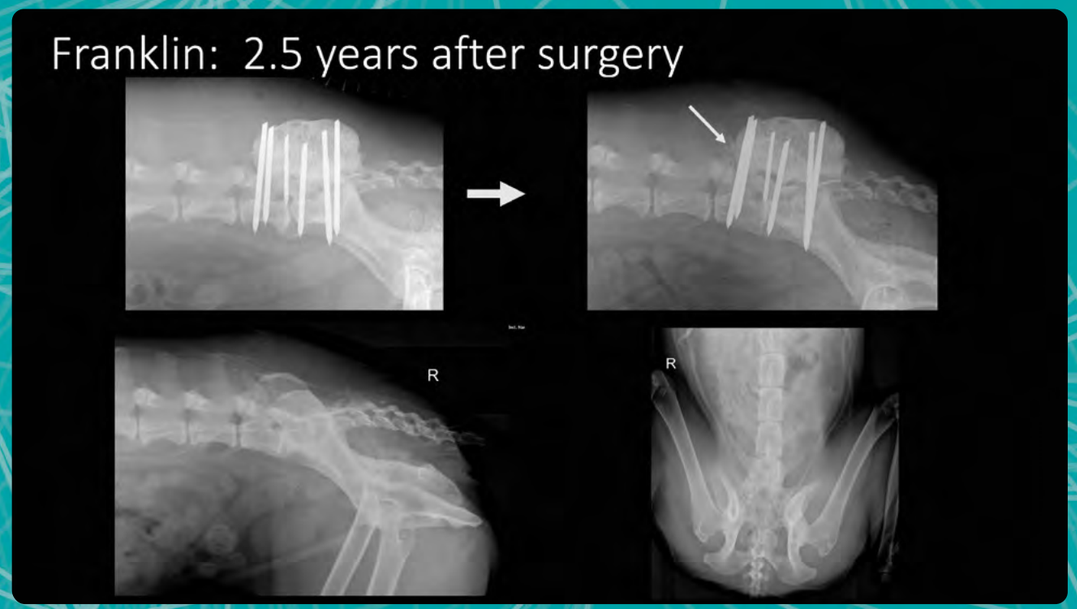
Franklin: 2.5 years after surgery


Franklin: 2.5 years after surgery
R
R

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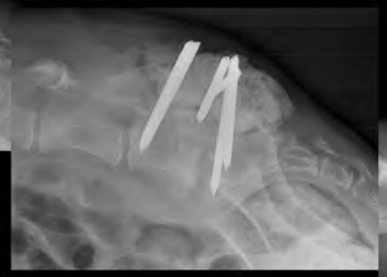
Problems with Current Fixation

- Fixation of LS Spine
  - Pins or screws in pedicles of lumbosacral spine
    - LS stabilization then accomplished by incorporating implants into PMMA
    - Potential Problems
      - Mass of cement
      - Infection
- SOP
  - Contour
  - Holes Limit placement of screws

Is There Another Way?



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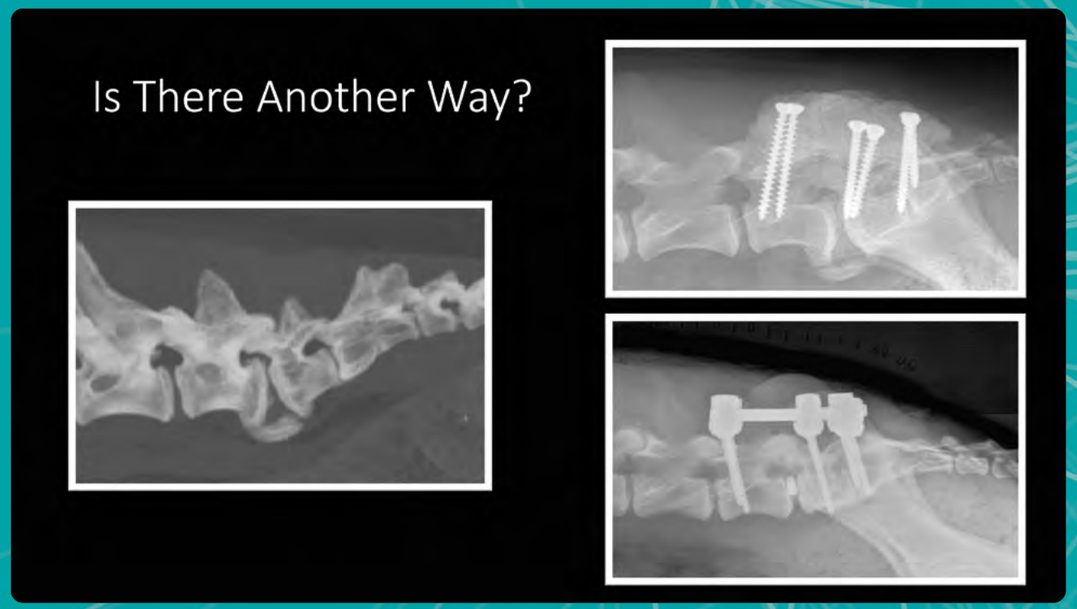
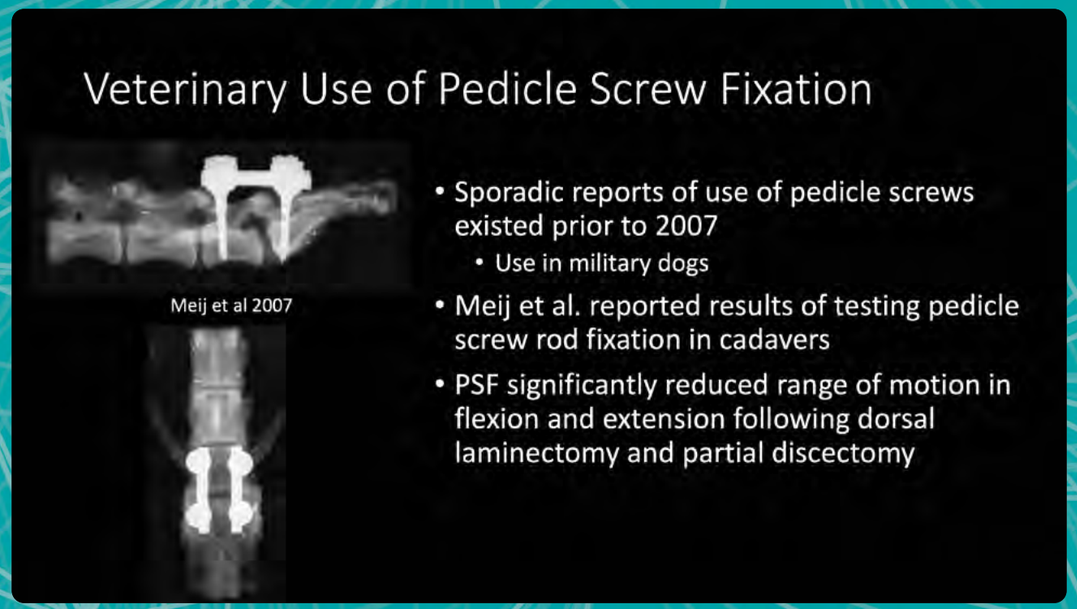


Veterinary use of Pedicle Screws



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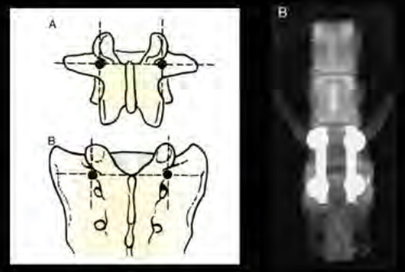
Veterinary Use



Meij et al 2007

- Authors established entry points for implants in L7 and S1
- Screw placement
  - Dorsal cortex was pierced with an awl
  - Pedicle probe used to create trajectory for screw
- Screw positioning
  - Utilized a convergent plane of 10-15° from midline
  - Meij et al. 2007

Veterinary Use

Smolders et al 2012

- Smolders et al 2012 presented preliminary work in placement of pedicle screws at L7-S1
  - Fixed trajectory screws
  - Same placement technique as Meij et al 2007
- Screws placed with free hand technique using pre-operative CT for planning
- 3 research dogs with mild lumbosacral disease were used as subjects for surgery
- No major problems clinically
  - Discospondylitis at L7-S1 in one dog
- Fusion not demonstrated

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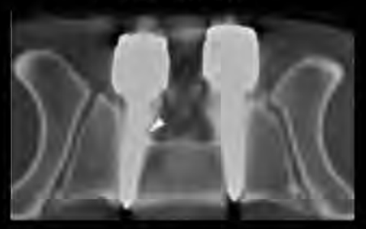
Veterinary Use

Smolders et al 2012



- *Smolders et al* 2012
  - Placement of screws deemed unacceptable for 33% of implants
  - Most significant problems related to breach of medial pedicle wall in 17% and penetration of disc space in 13%
  - Authors suggest *significant learning curve* exists for surgeons utilizing this technique
- Determined that pedicle screws used for adult humans (4.0 mm diameter) placed in convergent angle too big for pedicle of many medium and large breed dogs

Veterinary Use

- Tellegen and others (2015)
  - PSF in client-owned dogs with lumbosacral disease in 12 dogs
  - Fluoroscopy used to insure proper placement of pedicle screws
- Results
  - 8/12 had excellent outcomes with follow-up periods of 6 months to 4 years
  - 4/12 were considered to have improved

Notes

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Veterinary Use: Fusion?

- Fusion not identified in any dogs despite placement of autograft in disc space
- No evidence of interbody fusion on combination of radiographs/CT
- Fusion may not be as important in canine compared with humans due to limited lifespan of dogs
- Failure of fusion may have been due to thicker subchondral bone and thinner vertebral endplates in dogs compared to humans
- More aggressive removal of endplates to expose subchondral bone may have enhanced fusion?

Veterinary Use: Limitations of Pedicle Screws

- Cost of implants significant limiting factor for use of PSF in veterinary medicine
- Pediatric systems exist
  - Screws and tulips may still be limiting due to their excessive size
- Smaller screws, tulip and connecting bar needed
- Multiple potential applications for animals that require instrumented fixation

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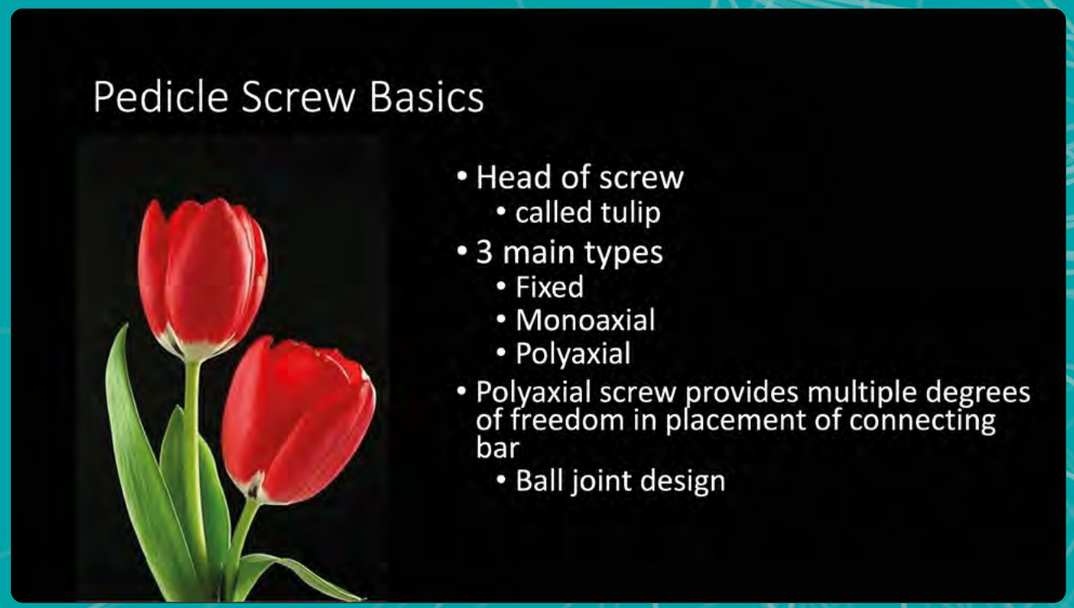
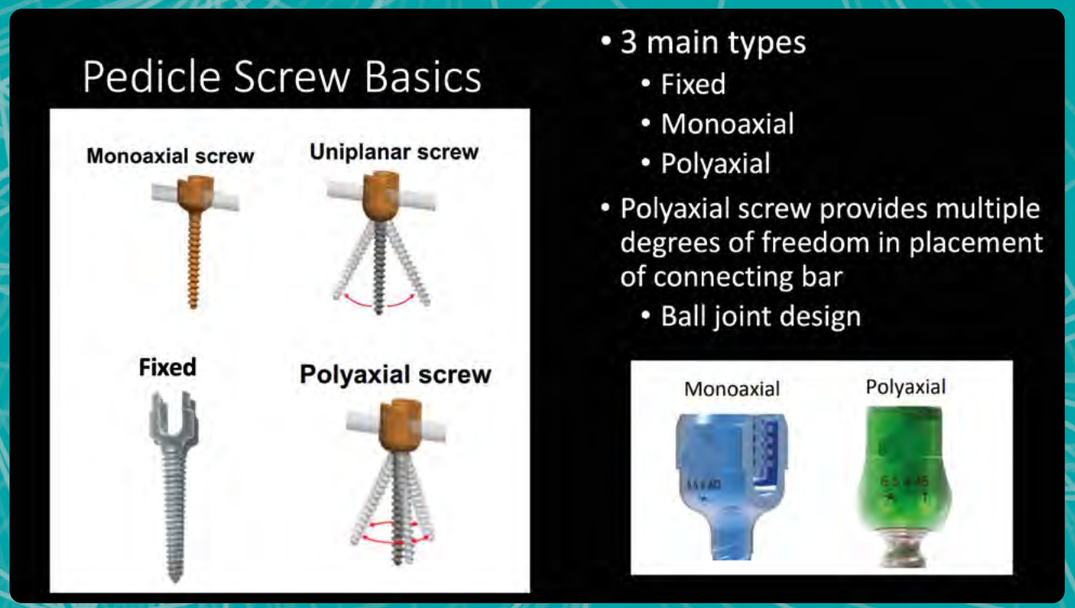
Pedicle Screw Basics





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Pedicle Screw Basics Polyaxial Screw

- Polyaxial screw provides greater rigidity in lumbosacral spine compared to a monoaxial screw used with a cage
- Polyaxial screw provides more flexibility in rod placement
- Less need for adjustment of screw depth and orientation for fitting rod
- Greater tilt provides an advantage at connecting bar-tulip interface
- Less contouring needed of connecting bar with polyaxial systems

PEDICLE SCREW BASICS

- Components of Pedicle Screw System
  - Screw
  - Head of the screw (also called tulip)
  - Connecting bar
    - Nut used to secure connecting bar to screw
- Screw portion of implant is what engages bone
  - Head
  - Neck
  - Body
  - Diameter of screw should be no more than 2/3 of width of pedicle

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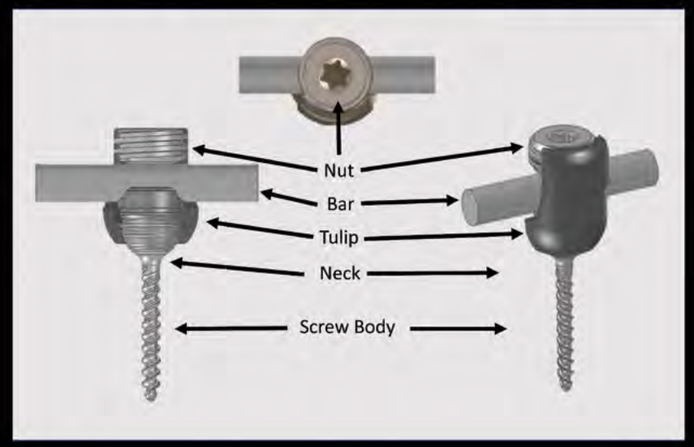
Pedicle Screw Basics Polyaxial Screw



Pedicle Screw Basics

- Connecting bar or longitudinal rod is placed in tulip and
  - Secured with an interlocking nut
- Connecting bar can span multiple levels
- Tulip Designed to fit a specific size connecting bar

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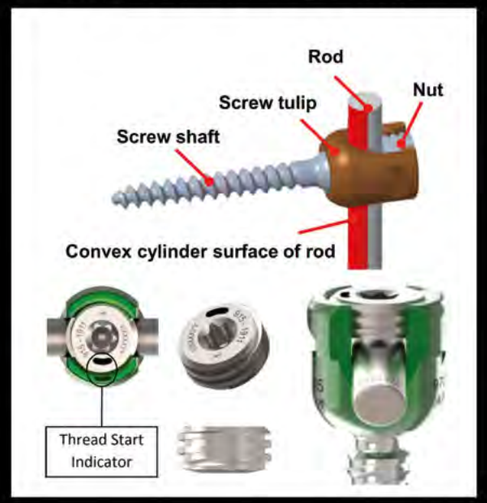
Pedicle Screw Basics



- Retentive force
  - Force needed to resist stresses on vertebral column to oppose motion at interface between tulip and rod

Pedicle Screw Basics

- Torque needs to be adequate to minimize the chances for loosening or slippage of rods
- Excessive tightening of nut could impact retentive force and lifetime of construct
- Nut is placed with torque limiting device
- Commercially available systems
  - Specific range of torque recommend to tighten nuts
  - Range varies between systems
    - 3.7-12 Nm

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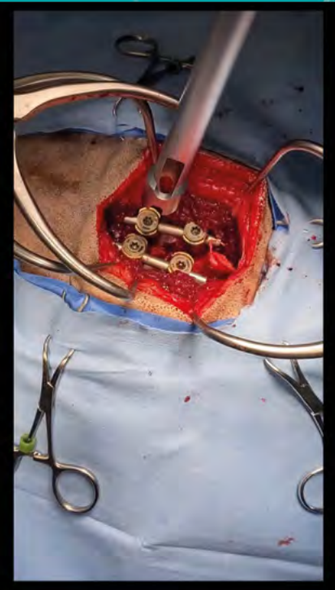
Torque Limiting Wrench



Pedicle Screw Fixation

- Can be combined with other implants
  - Promotes stability and enhances fusion
    - Plate
    - Cage

Notes

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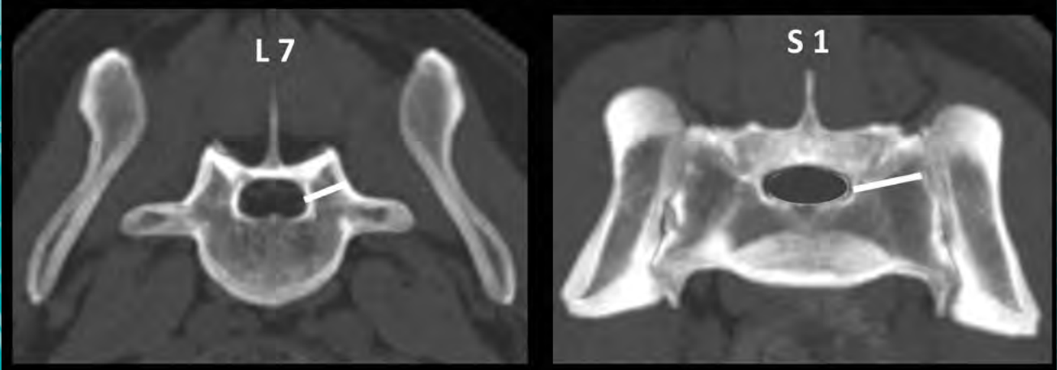
Pre-operative Planning

Preoperative Planning: Basic Considerations

- Imaging:
  - CT is a very usual imaging modality for planning stabilization
  - MRI can be used
- Understanding of points of insertion of pedicle screws is essential
- Diameter of pedicle screw is based on width of pedicle at L7 and S1

Preoperative Planning

- Diameter not larger than 2/3 of the width of pedicle



Transverse CT reconstructions that demonstrate approximate measurement of the pedicle for determining size of the pedicle screw to be used

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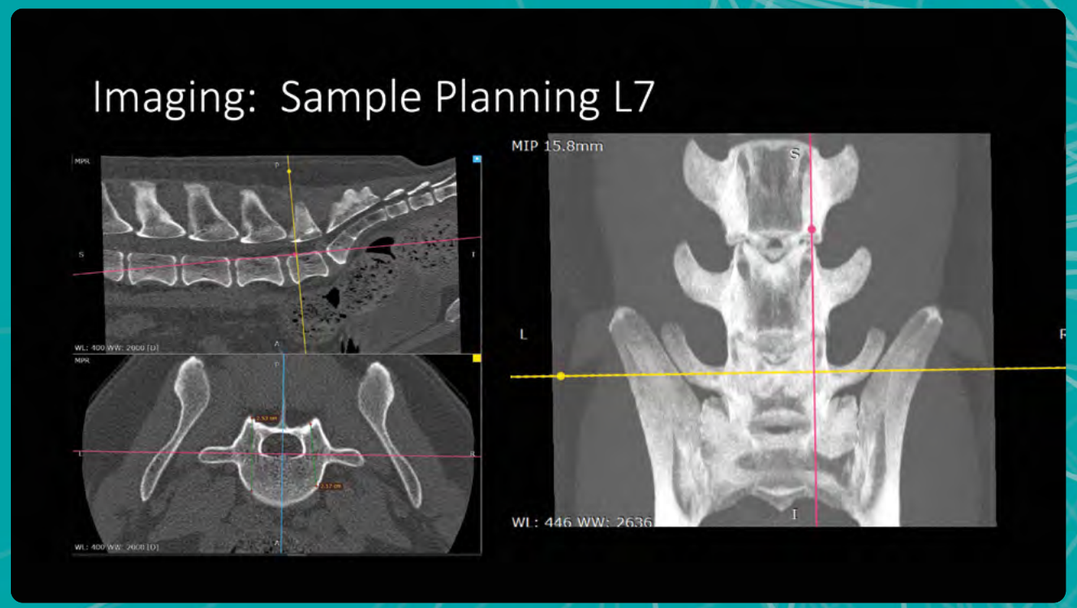
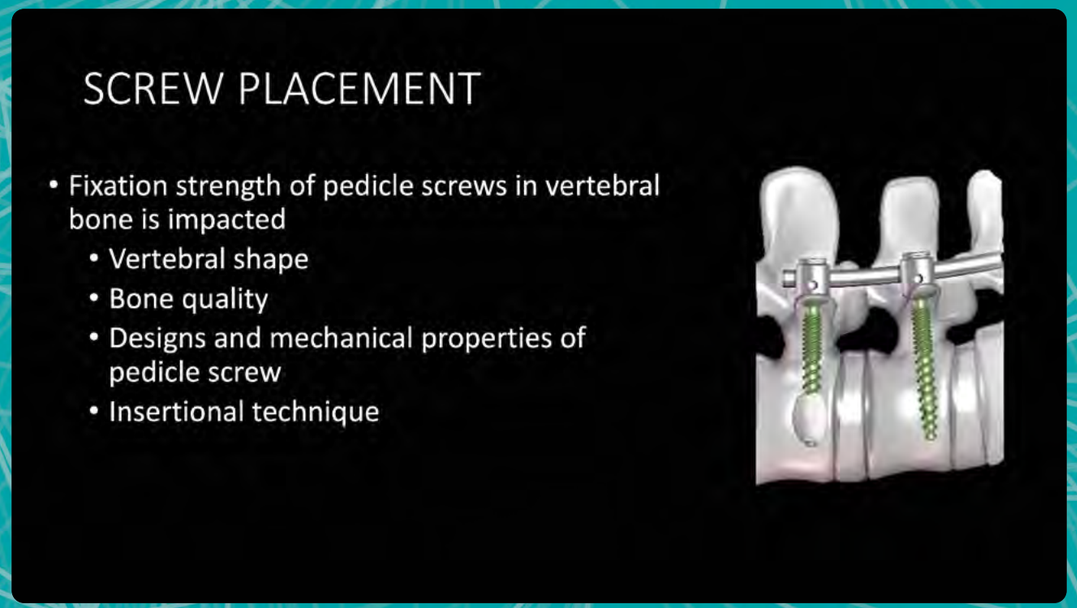
Screw Placement





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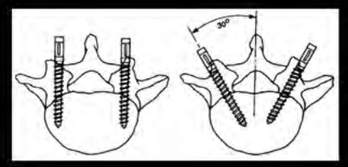
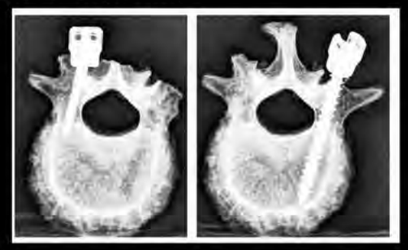
Screw Placement: Trajectory in Humans

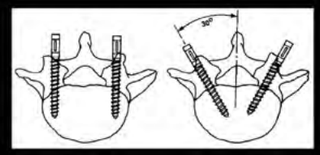
- Two Directions
- Traditional convergence by 30% (dorsal plane)
  - Relative to midline
  - Screw is placed at an 80% depth in bone (vertebral body) with this method
- Laterally directed cortical bone trajectory





Screw Placement: Trajectory

- Insertion without convergence has been shown to be more stable for linking segments in longitudinal fashion
- Santoni and others 2009 advocated laterally directed cortical bone trajectory
- Trajectory described in veterinary literature for implant placement (Ex Fix Pins)



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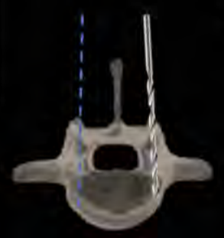
Screw Placement: Methods



- Three basic placement methods for screws
- Free hand method uses pre-operative planning based on imaging and anatomy
- Other methods are fluoroscopy guided or CTguided/stereotactic placement

Screw Placement

- First - adequate exposure of bone to identify anatomic landmarks
- Entry point is identified
  - Awl or bur piecers dorsal cortex to identify underlying cancellous bone
- Size of hole in dorsal cortex limited to preserve cortical bone-screw interface to help maintain solid fixation
- Use of preoperative radiographs and CT aids process for deciding where to place screws

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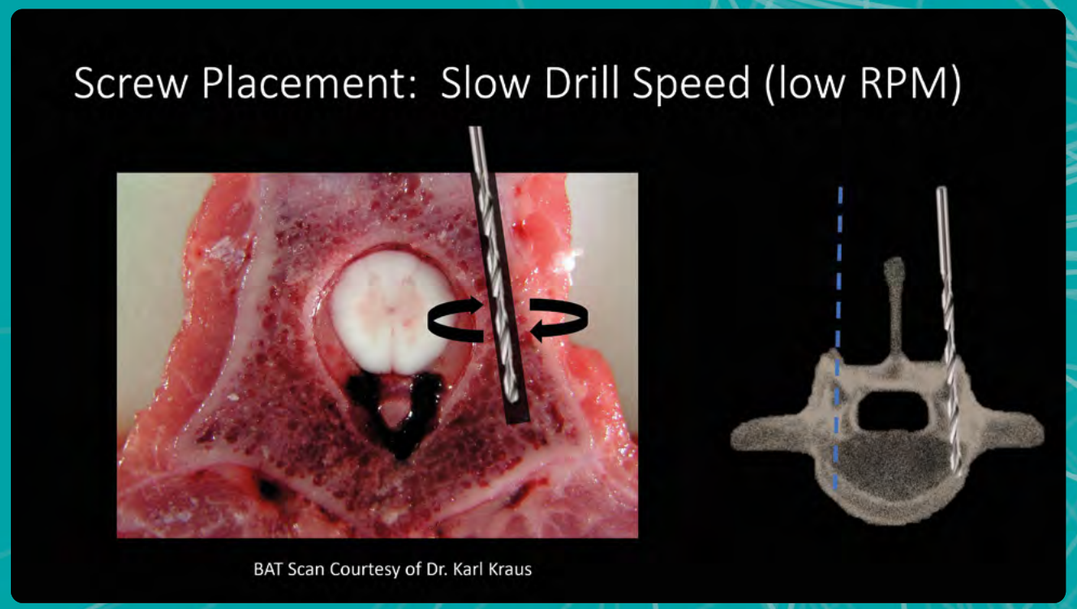
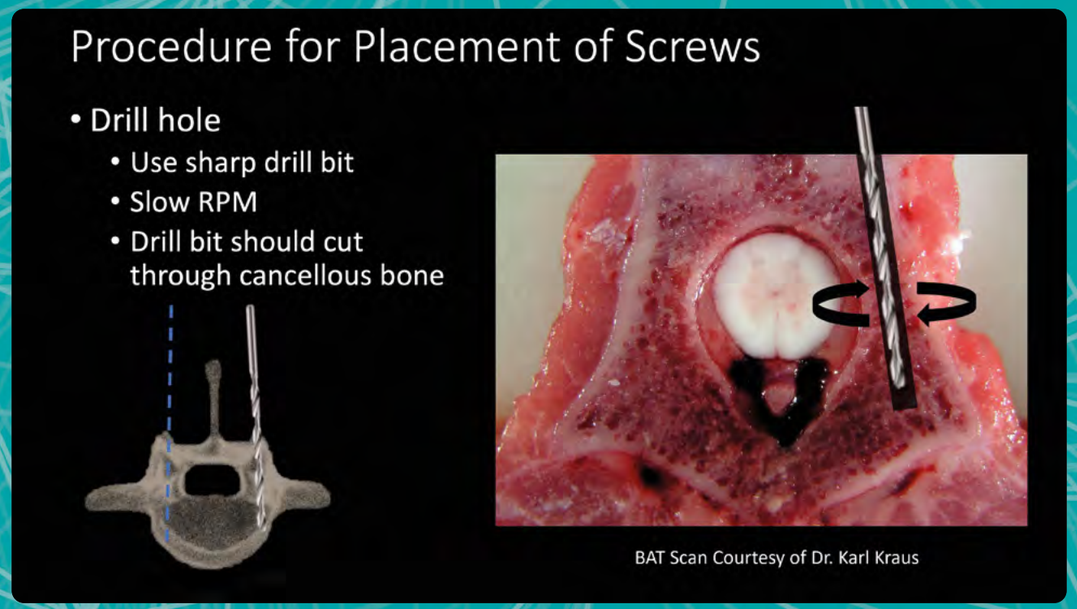
Procedure for Screw Placement and Instrumentation





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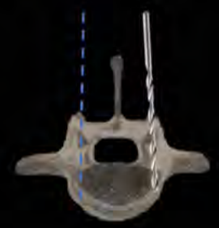
Instrumentation: Sounding Probe

Screw Placement

- Prior to screw insertion
- Pedicle wall evaluated with a ball tipped probe to identify any violations (breaches) in walls of pedicle



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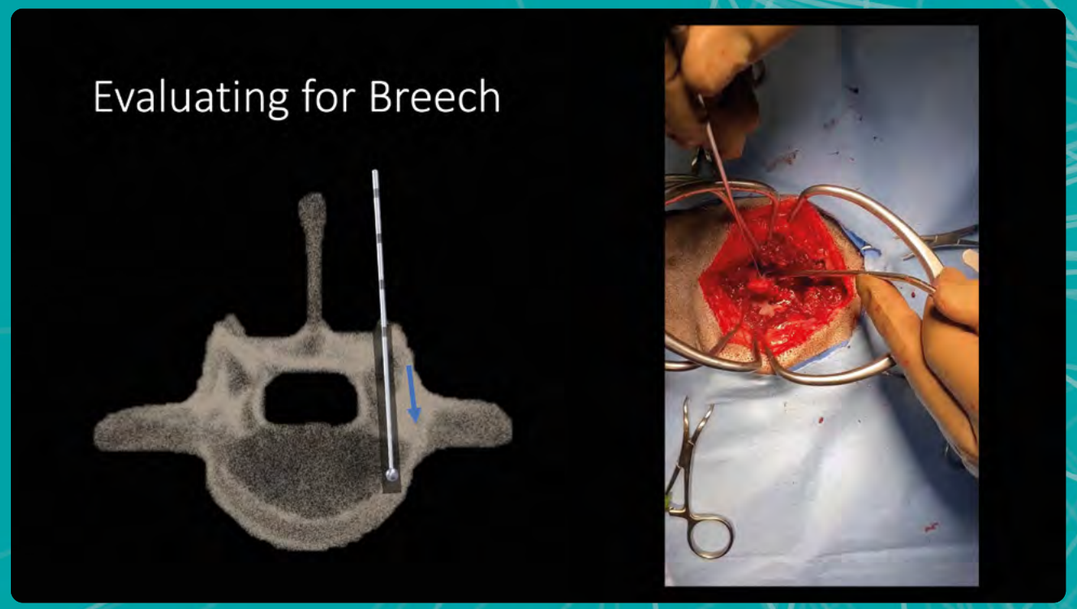
Evaluating for Breech

Placement of Screws
• Hole drilled using appropriate drill size
• Ball tipped probe used to evaluate for possible breeches of corridors
• Measure depth of hole using depth gauge or probe
• Allow for an additional 2-5 mm of screw not placed in the screw hole
• Hole does not need to be tapped

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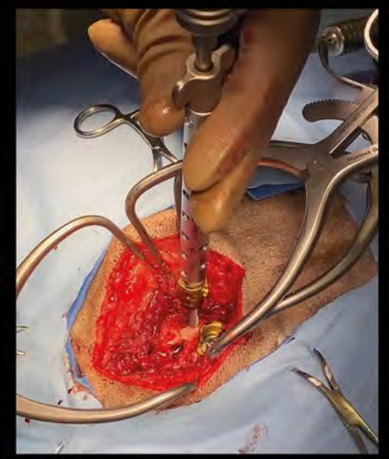
Screw Placement

- Hole measured
- Can be tapped
- Screw is inserted

Instrumentation: Locking Driver



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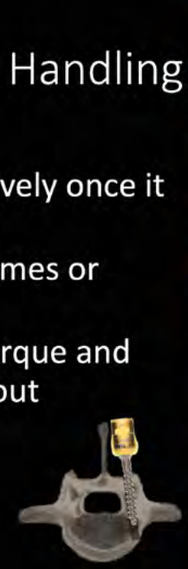
Screw Placement

- Prior to screw placement be sure nothing impedes proper placement of screw
  - Spinous process of L7
  - May inadvertently redirect screw trajectory
  - Results in medial breach
  - Remove spinous process

Screw Placement: Screw Handling

- Do not manipulate screw excessively once it has been placed
  - Avoid reinserting it multiple times or backing it out excessively
  - Process reduces insertional torque and subsequently can reduce pullout strength



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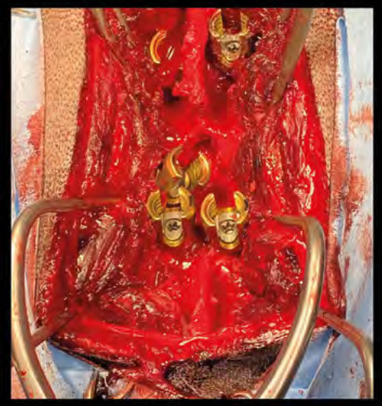
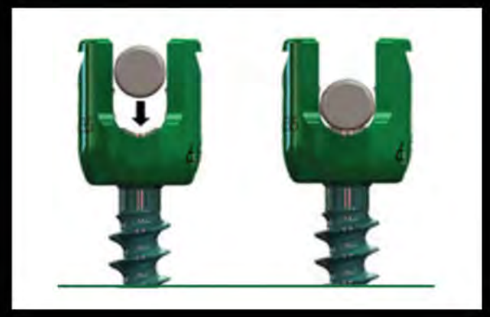
Screw Placement

- About 5 mm of neck left exposed to facilitate movement of tulip and placement of rod





Pedicle Screw Instrumentation: Become Familiar with Equipment

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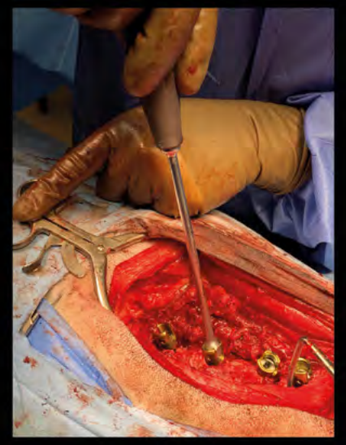
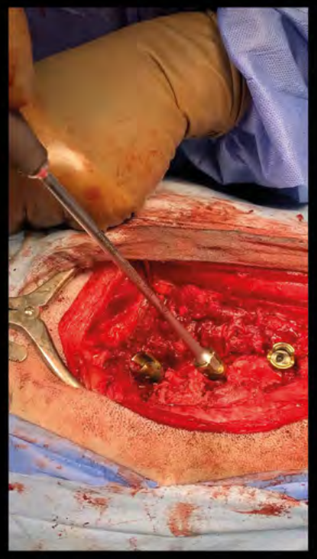
Instrumentation: Head Positioner

Position Tulips





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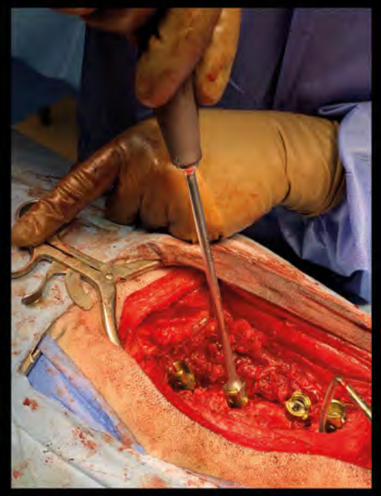
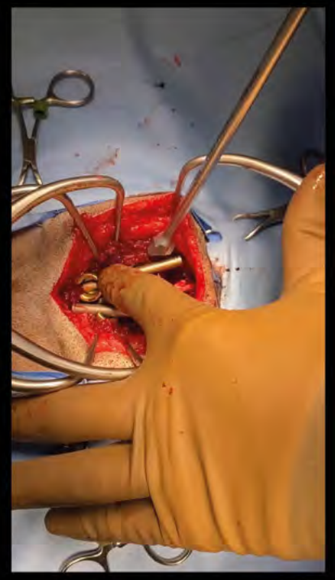
Position Tulips

- Use head positioner to place tulips in desired position to accommodate bar



Place Bar In Tulips



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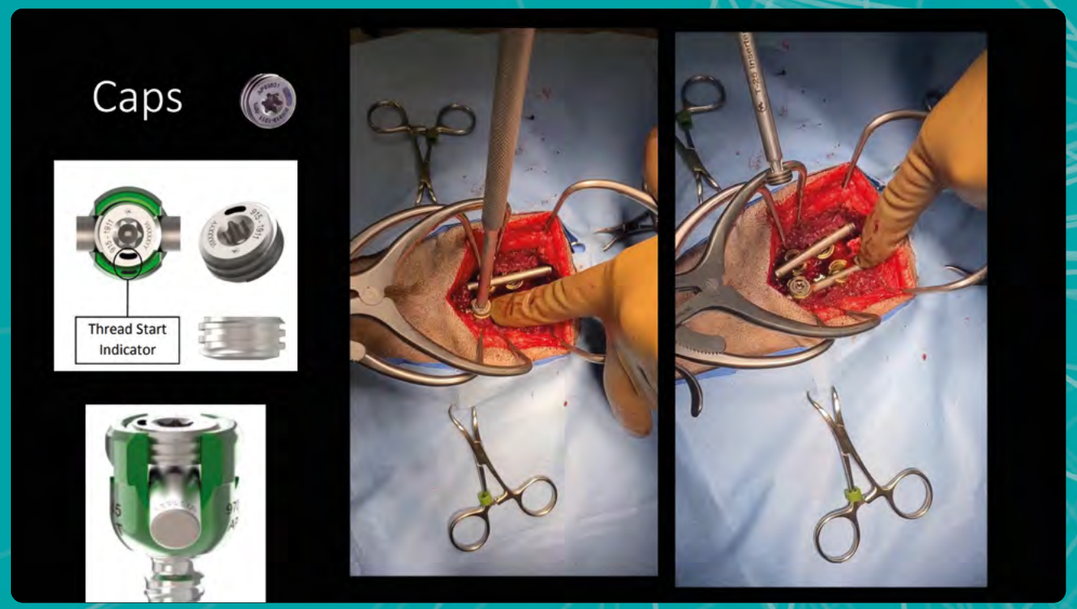
Caps
Thread Start Indicator


Instrumentation: T25 Inserter (for caps)

Notes

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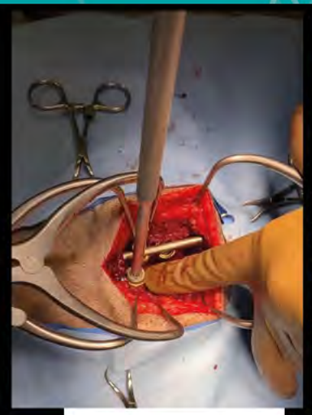
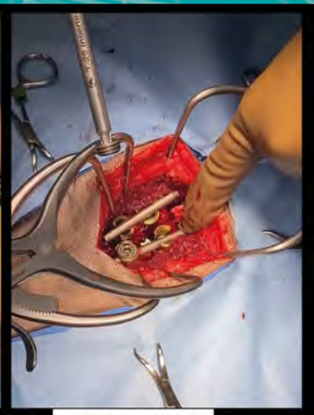
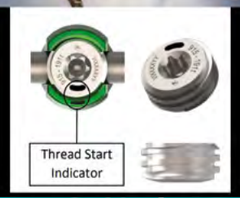
Caps

- Place caps in each tulip to secure bar
- Do not over tighten
  - Just enough to maintain position of bar
- Optimal retentive force
- Overtightening may distort bar
  - Lead to implant uncoupling







Instrumentation: 3.7 N Torque Limiting Device

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Instrumentation: Counter Torque Wrench

Torque Limiting Wrench

- Use torque limiting wrench to apply final cap to avoid over tightening
- Counter Torque device should be used to secure tulip and bar
- When the proper torque is applied the device will “pop” or clique to indicate proper tightening

Notes

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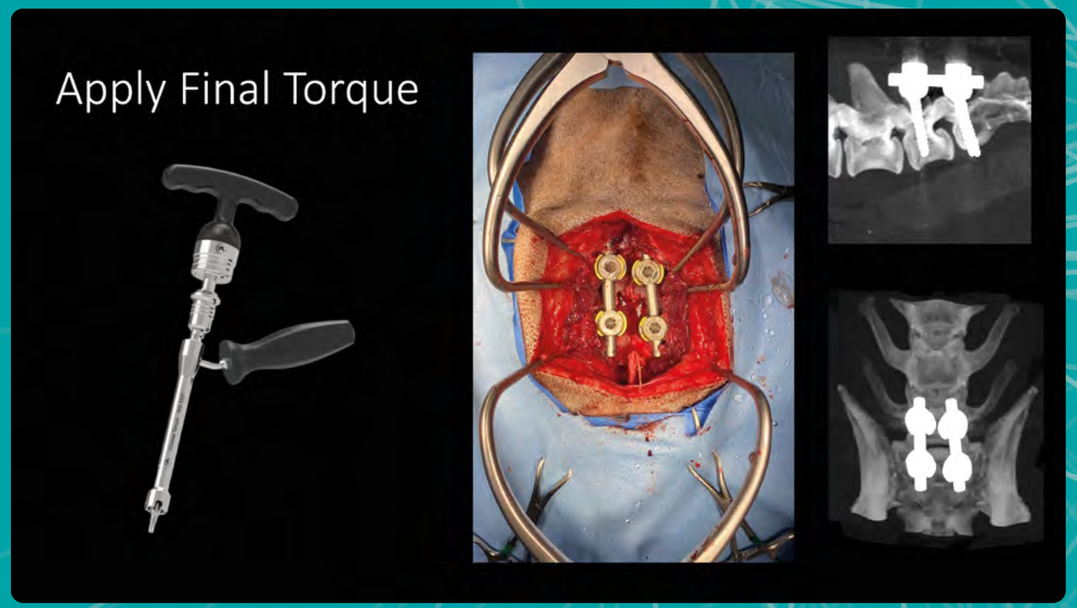
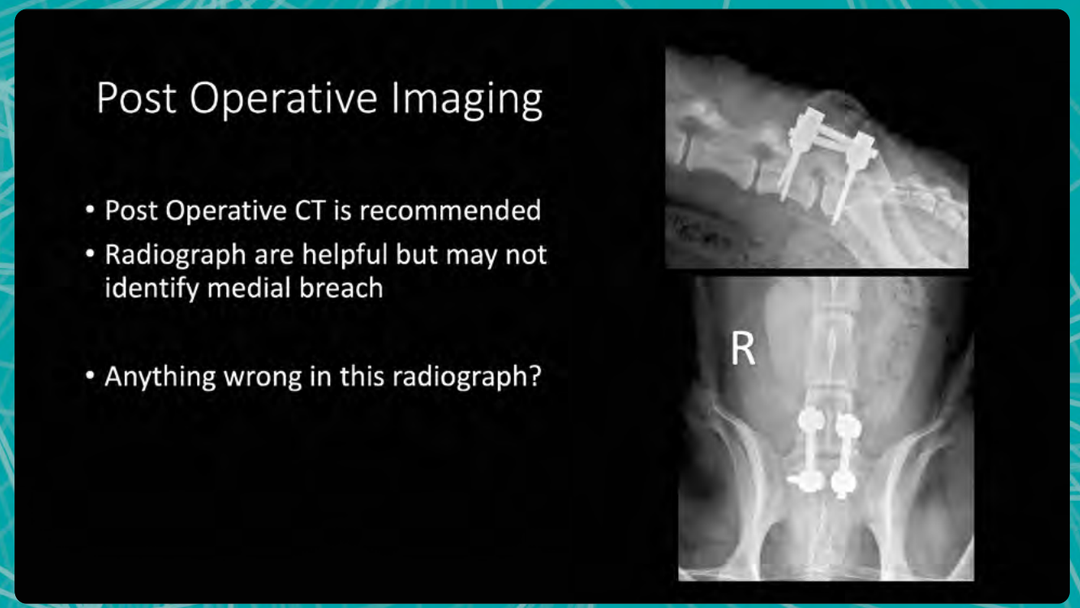
Post-Operative Imaging





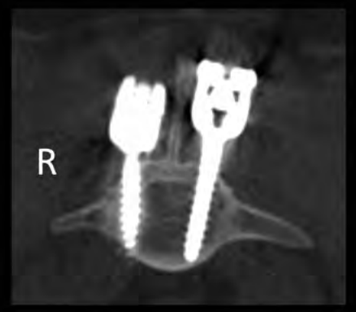
Notes

Notes

Complications and Revision

Post Operative Imaging

- Post Operative CT is recommended
- Radiograph are helpful but may not identify medial breach



COMPLICATIONS

- Malposition results in cortical breach of pedicle either in lateral or medial direction
- Parameters for acceptable breach include medial (2 mm tolerated) and lateral (4 mm tolerated)
- Screw misplacement can result in neural injury to either nerve roots or spinal cord


Ventral Breach


Medial Breach

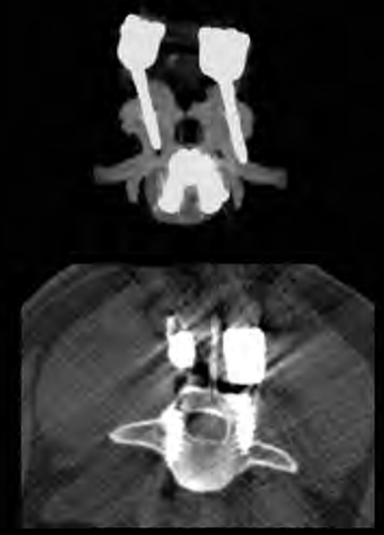

Lateral Breach

Notes

Notes

COMPLICATIONS

- Screw misplacement can be major complication
  - Cervical vertebral column
- Humans: damage to vertebral artery in cervical spine can have serious consequences
- Post-operative CT can be done to evaluate breach
  - Metal artifact can alter interpretation by up to 25%



Complications

- Screw breakage

Images courtesy of Dr. Scott Rutherford

Notes

Notes

Complications

- Bending of screws

Complications

- Infection
  - Lucency around screws
  - Proliferation of bone
  - Usually associated with pain

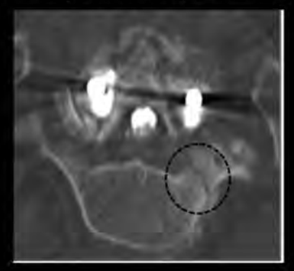
Notes

Notes

Complications

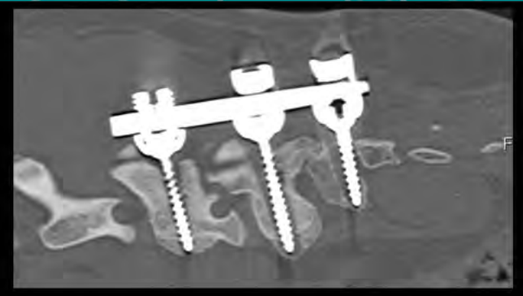
- Pars/Pedicle Fracture

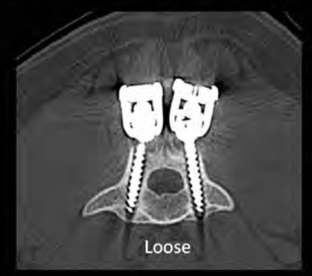
W.K. Cheng et al. / The Spine Journal (2015)



Complications

- Loosening of screws
  - Nonunion and micromotion of screws over time leads to forces overloading fixation strength of bone screw interface
  - > 2mm lucency around screws on CT





Notes

Notes

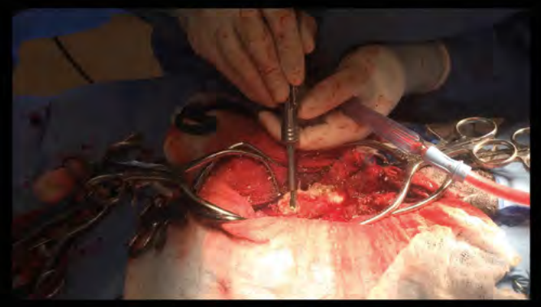
Complications

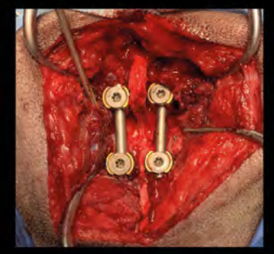
- Adjacent segment disease

Young et al. Complications of Spinal Instrumentation. RadioGraphics 2007; 27:775–789

Revision

- Revision surgery is much simpler than when PMMA is used





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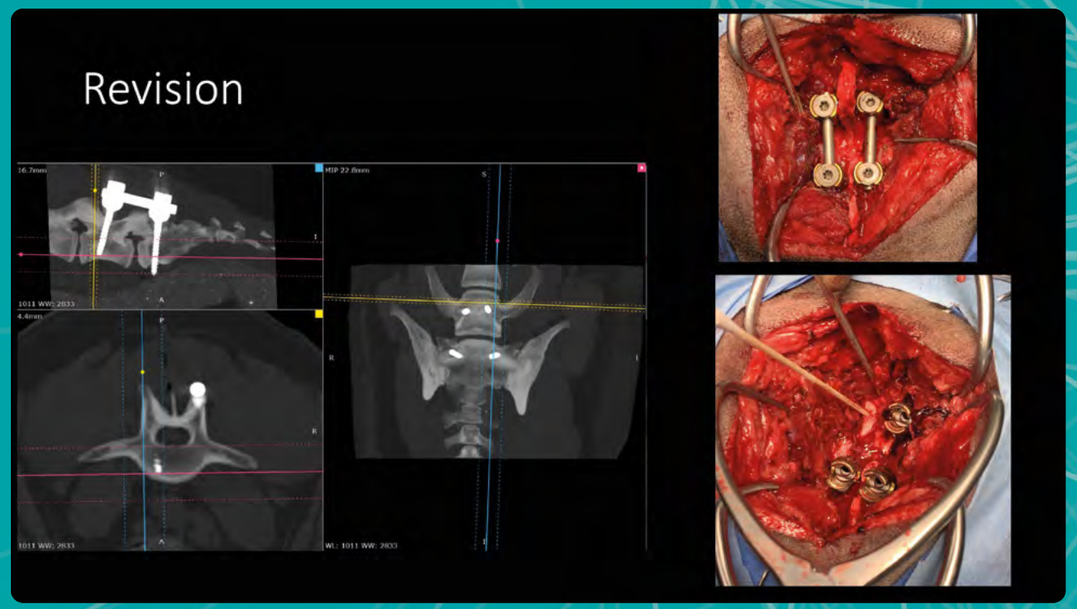

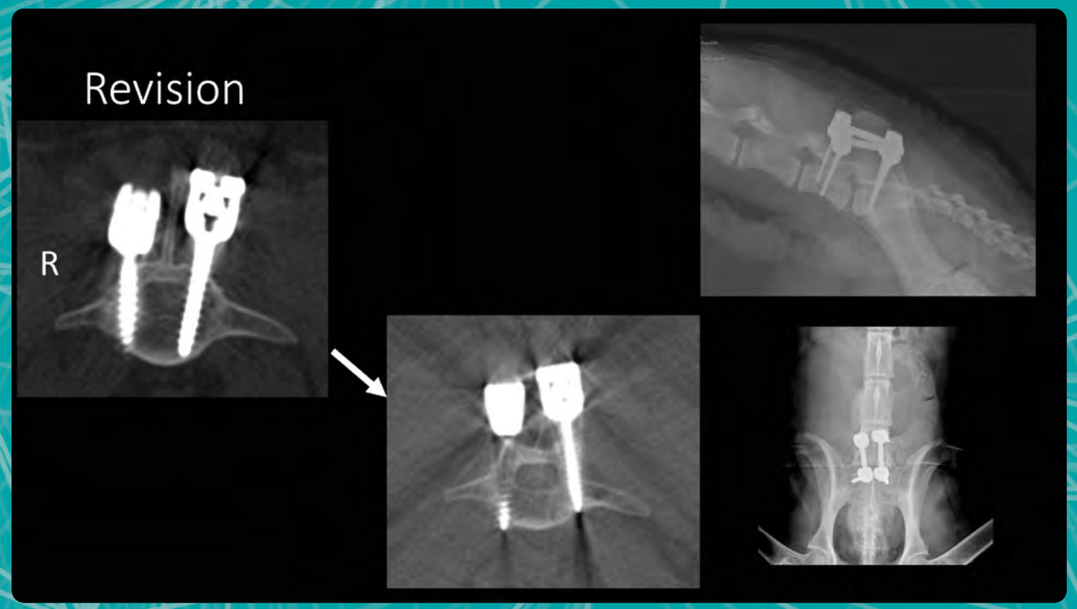

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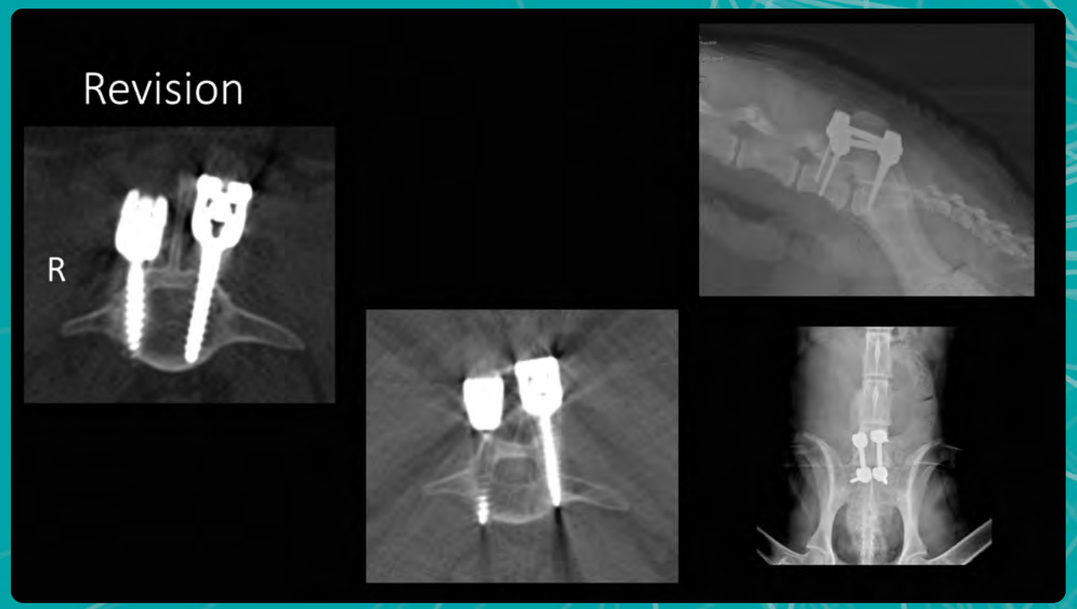
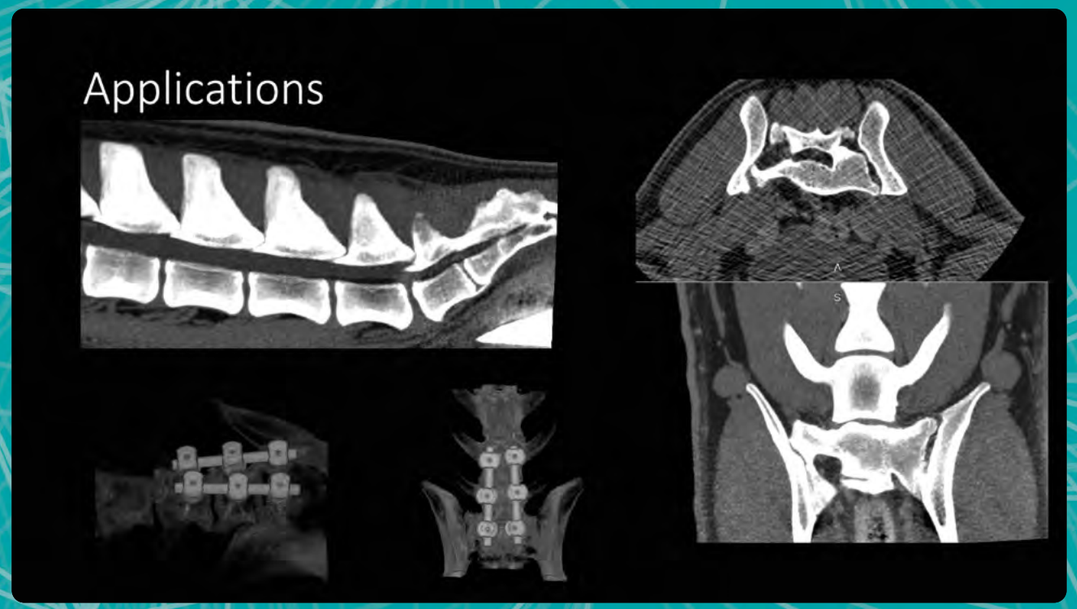
Applications



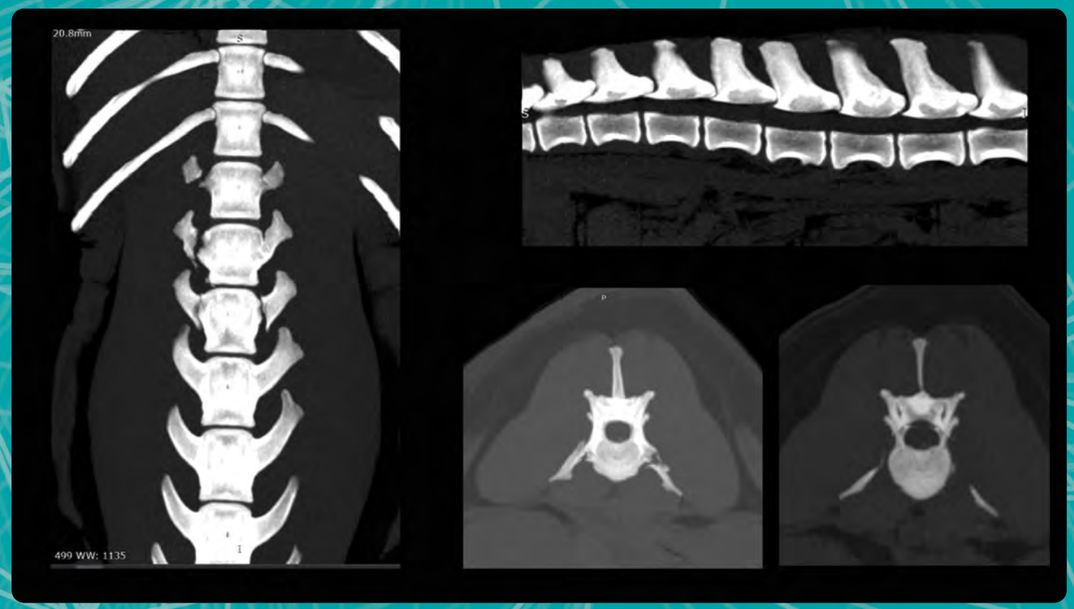


Notes

Notes

Applications

- Pedicle screw fixation systems to dogs and cats may prove to be valuable tool for treating conditions of vertebral column
  - Thoracolumbar spine
    - Lumbosacral disease
    - Lumbar/lumbosacral fractures
    - Thoracolumbar instability or fractures
    - Discospondylitis
  - Cervical Spine
    - Stabilization for cervical spondylomyelopathy
    - Augmentation of ventral stabilization following pseudoarthrosis
    - Infection of surgery sites
    - Trauma



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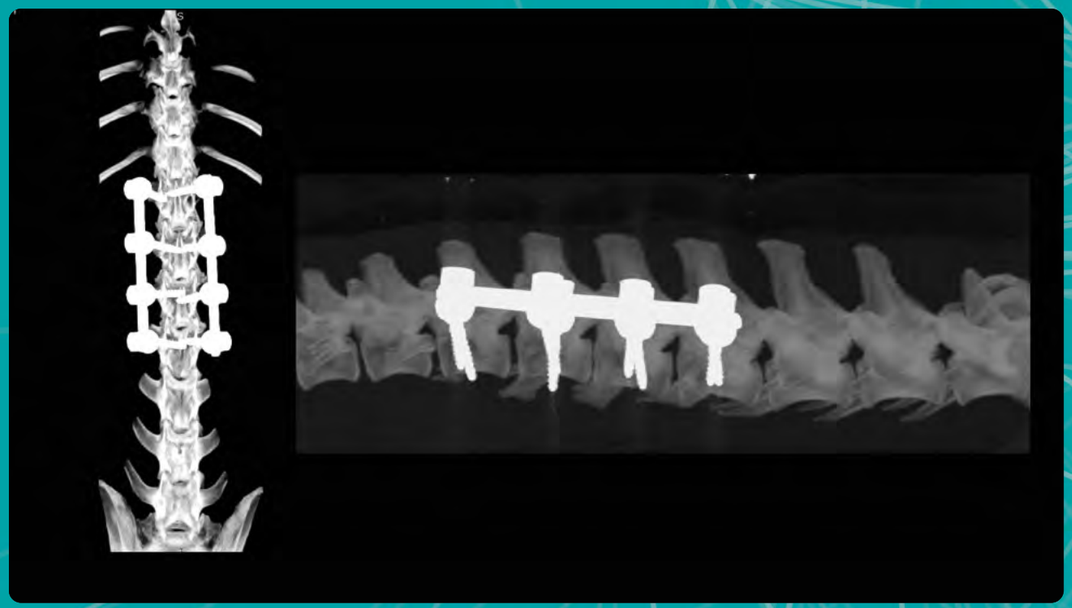


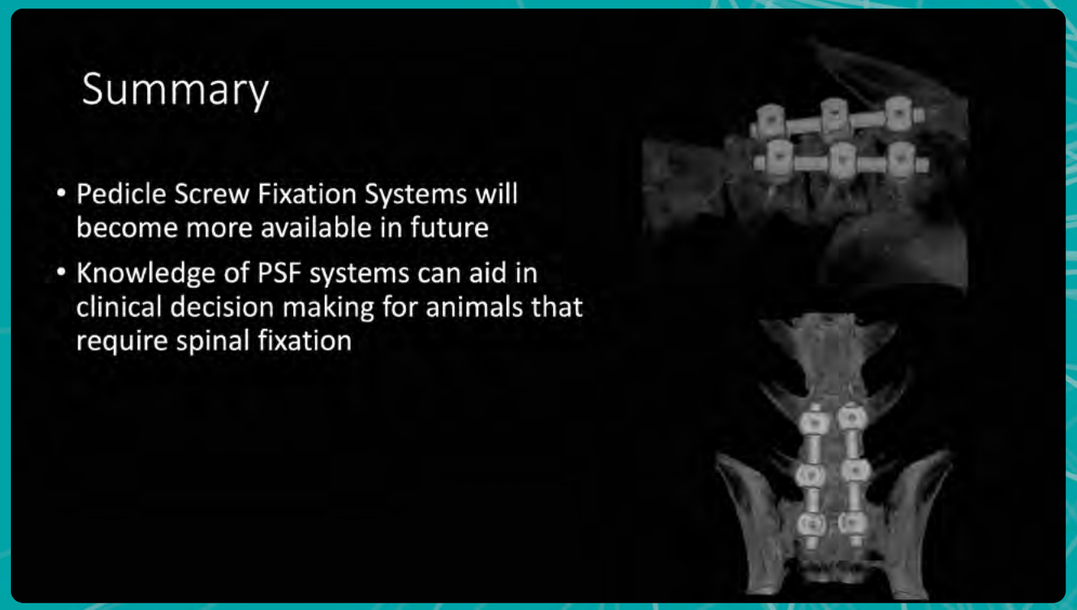
FUTURE DIRECTIONS

- Pedicle screw systems become smaller
- Use for multiple applications in small animals
- Screw sizes, tulips sizes, and connecting rods scaled to fit many veterinary patients
- Future Directions
  - Most conditions currently treated with screws/pins/PMMA potentially amenable to use of PSF

Notes

Notes

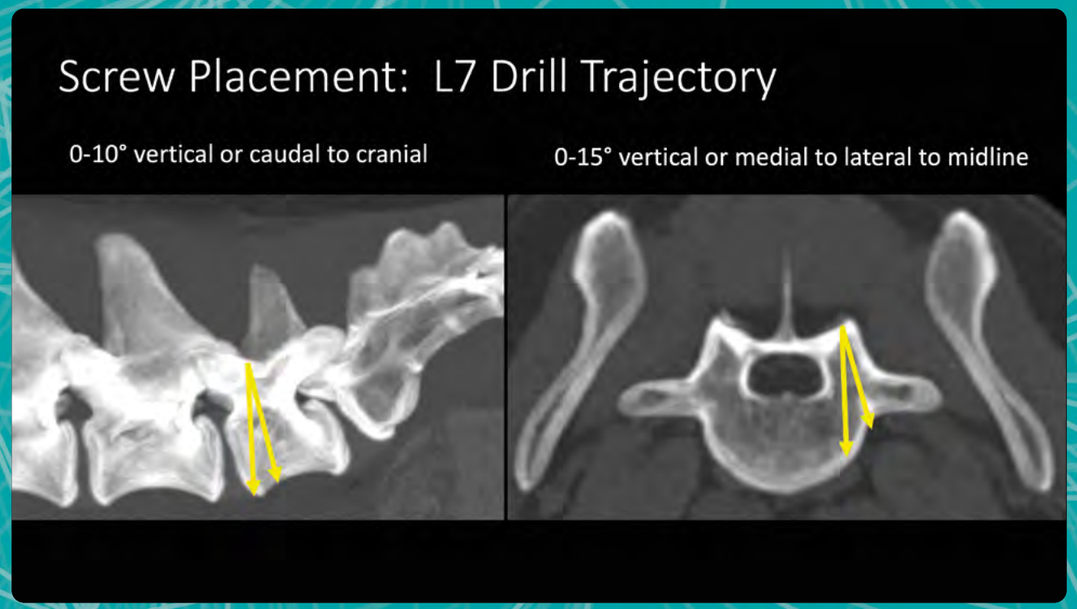
Summary



Notes

Labs

L7-S1 Stabilization



Notes

Notes

Screw Placement: S1 Drill Trajectory

0-10° vertical or caudal to cranial

0-10° vertical or medial to lateral to midline

Preoperative Planning

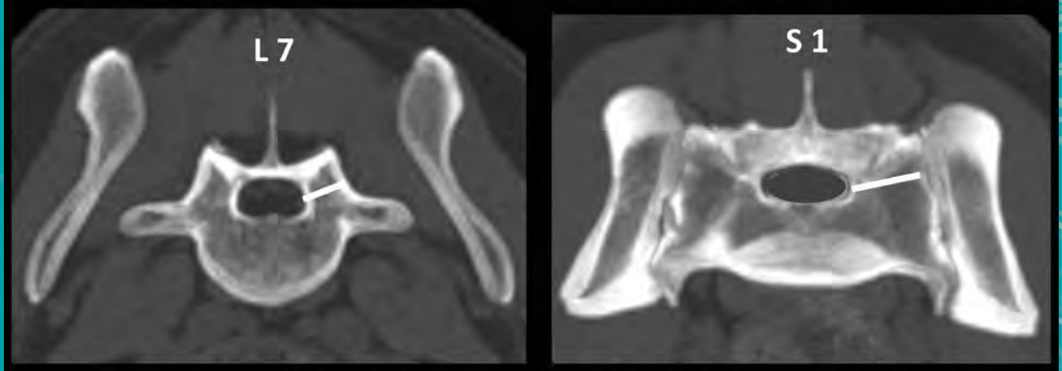
- Understanding points of insertion of pedicle screws is essential
- CT for planning L7-S1 stabilization
- 3D MPR can aid in proper implant placement
  - Radiant Viewer is a DICOM viewer
- MRI can be used
  - T1 and Proton Density Sequences are helpful to evaluate bone of vertebrae

Notes

Notes

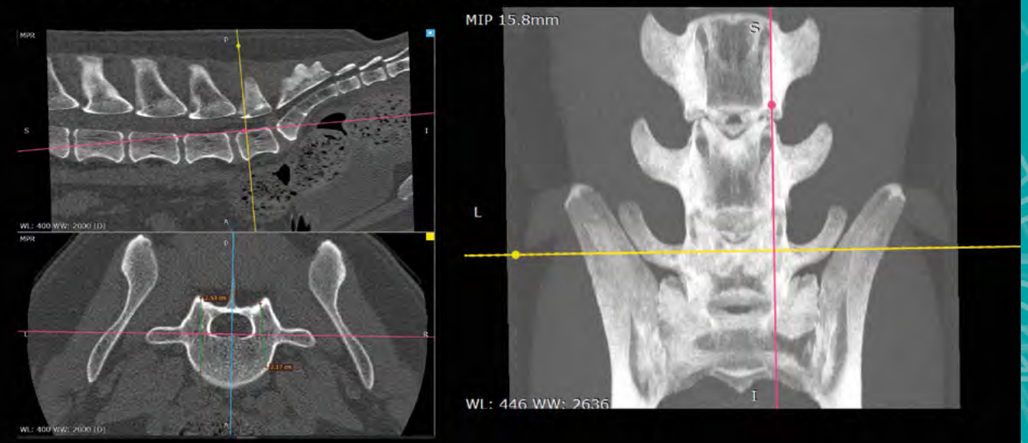
Preoperative Planning

- Diameter not larger than 2/3 of the width of the pedicle



Transverse CT reconstructions demonstrate measurement of pedicle for determining size of pedicle screw

Imaging: Planning L7 with 3D MPR CT



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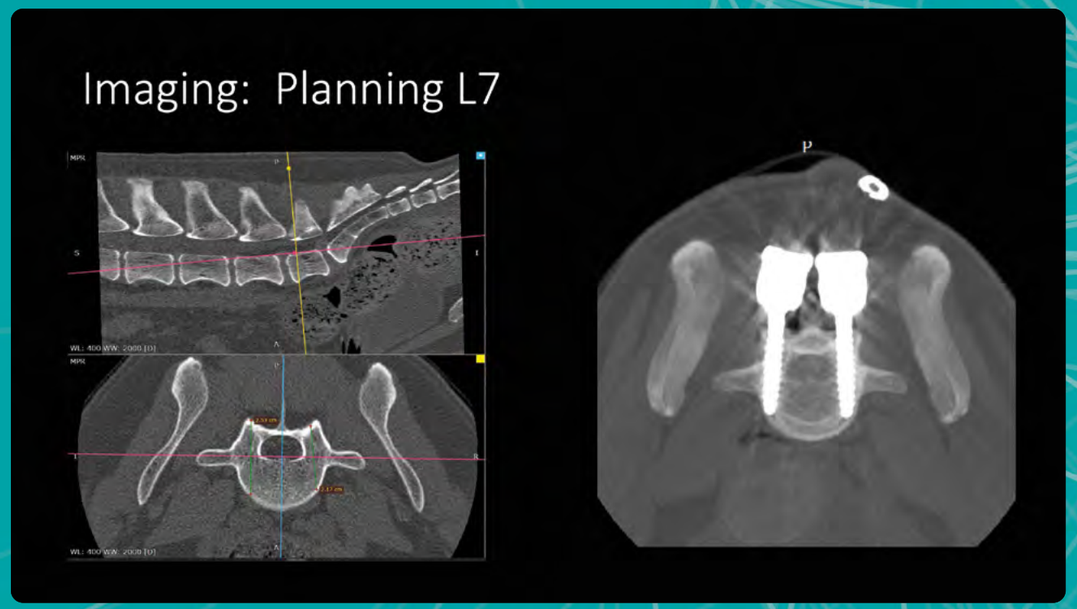
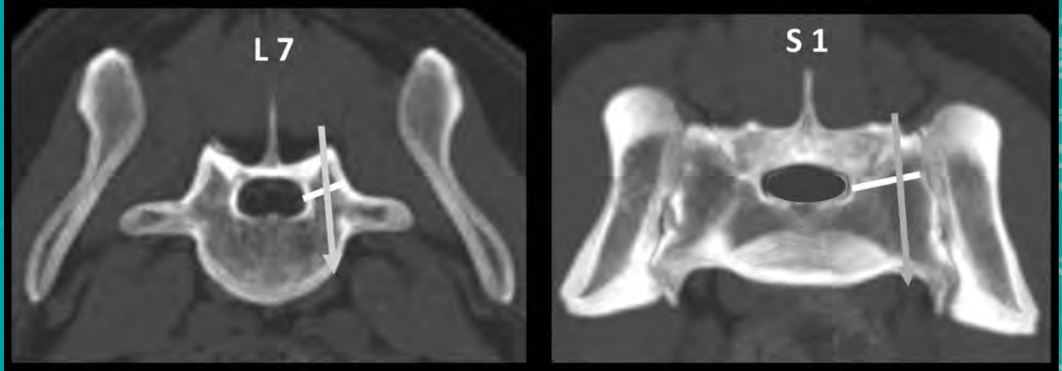

Imaging: Planning L7
MPR
P
S
I
A
WL: 400 WW: 2000 [D]
MPR
L
R
A
P


Imaging: Planning S1
MPR
P
S
A
MPR
L
R
MPR
P
A

Notes

Notes

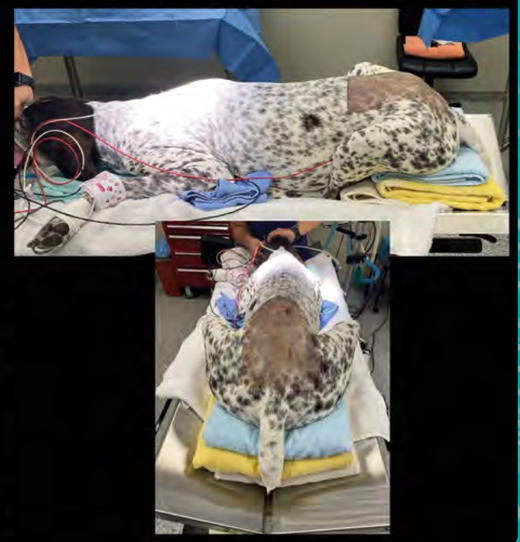
Screw Trajectory



Recommended trajectory of the screws is also considered in this measurement
Trajectory is 10-15° medial to lateral (divergent) as well as 10-15 ° caudal to cranial

Patient Positioning

- Dog placed in sternal recumbency with rear legs flexed forward
  - Opens disc space and interlaminar space allowing for better access to area of interest
  - Can also be placed in neutral position
- Towel under the dog allow for better positioning



Notes

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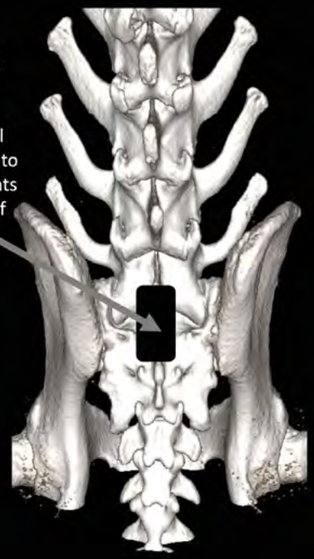
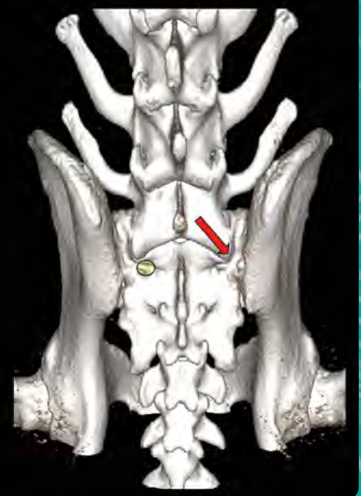
Landmarks for Dorsal Laminectomy

Relatively narrow dorsal laminectomy to preserve points of insertion of screws



Placement of Screws In S1

- Identify proper site of screw insertion in S1
  - Be sure to go lateral enough to identify the articular facet of L7-S1
    - Use a #15 scalpel blade to identify joint space (**red arrow**)
    - Drill hole and screw will be placed in fossa directly behind articulation of L7-S1
    - Overlying fat should be removed to clearly identify fossa (**yellow**)
    - *Failure to identify fossa is a common mistake
    - Angle 10-15 ° medial to lateral
    - Angle 10-15 ° caudal to cranial

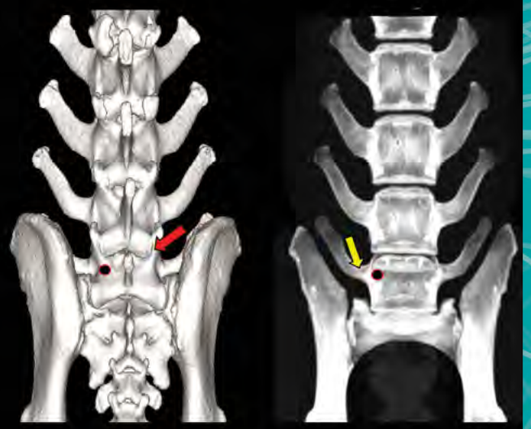


Notes

Notes

Placement of Screws In L7

- Identify proper site of screw insertion in L7
  - Be sure to go lateral enough to identify articular facet of L6-L7
    - Use #15 scalpel blade to identify joint space of L6-7 (red arrow)
    - Drill hole and screw will be placed in the bone caudal to joint (Red dot)
    - Use transverse process (yellow arrow) to help identify proper insertion location
      - Angle 10-15 ° medial to lateral
      - Angle 10-15 ° caudal to cranial



Placement of Screws

- Identify sites of screw insertion
- Recommend drilling outer cortex with a 1 mm burr
- Pre-drill use appropriate drill size
  - 4.5 mm pedicle screw - 3.2 drill bit
  - 3.5 mm pedicle screw - 2.5 drill bit
  - 2.7 mm pedicle screw - 2.0 drill bit
  - 2.0 mm pedicle screw – 1.5 drill bit

Notes

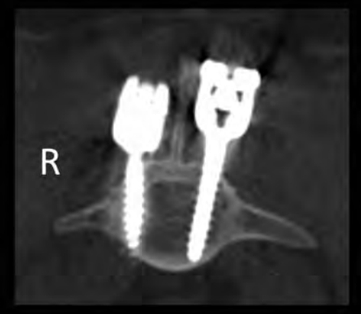
Notes

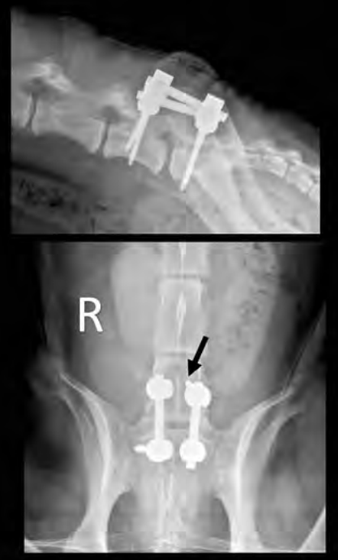
Post Operative Imaging

- Post Operative CT is recommended
- Radiograph are helpful but may not identify medial breach

Post Operative Imaging

- Post Operative CT is recommended
- Radiograph are helpful but may not identify medial breach

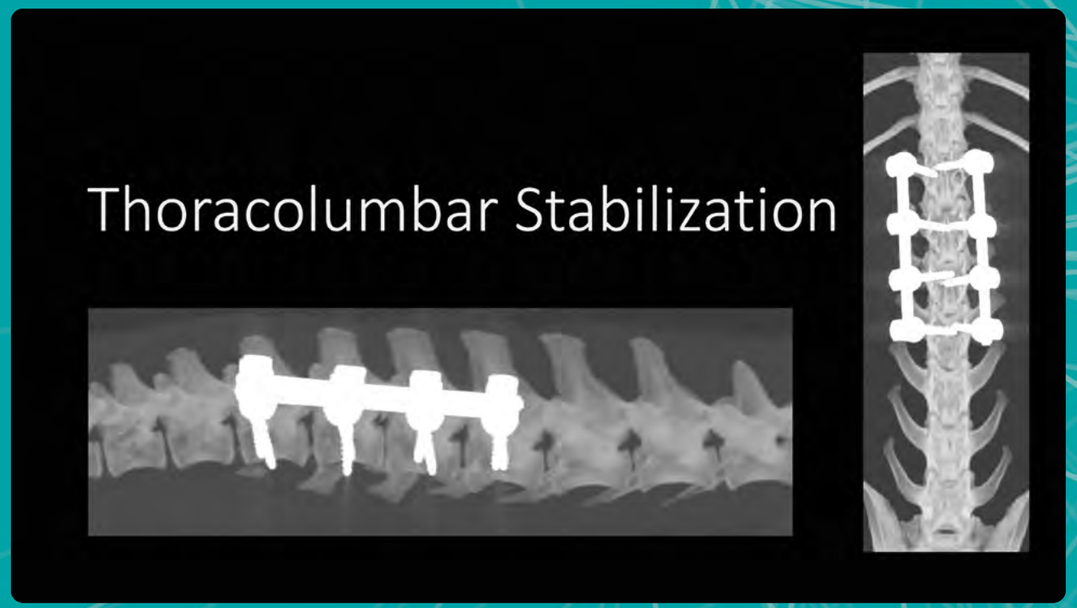


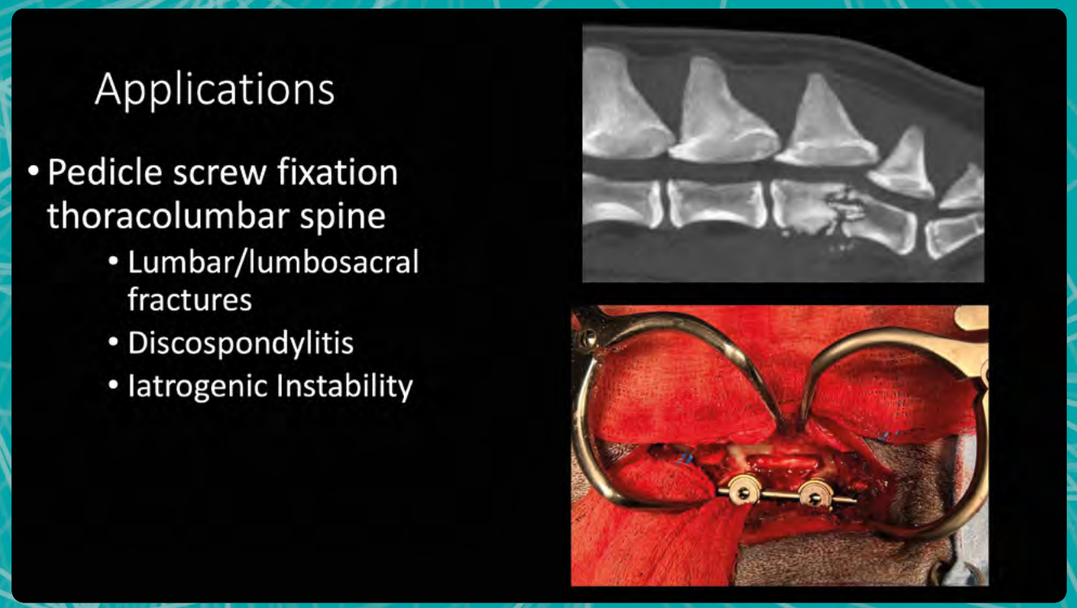


Notes

Notes

Thoracolumbar Stabilization





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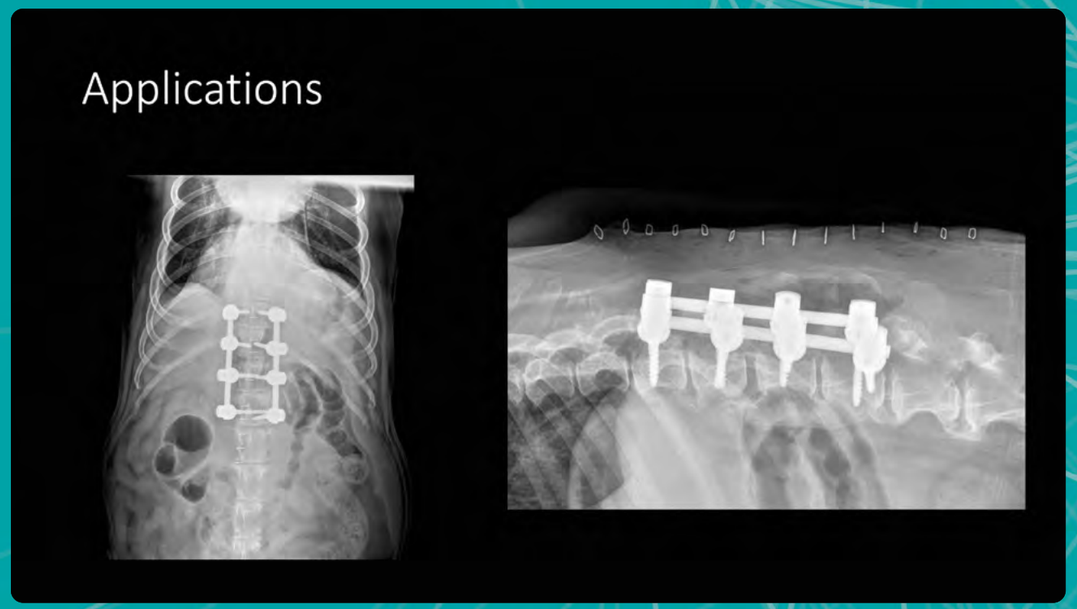

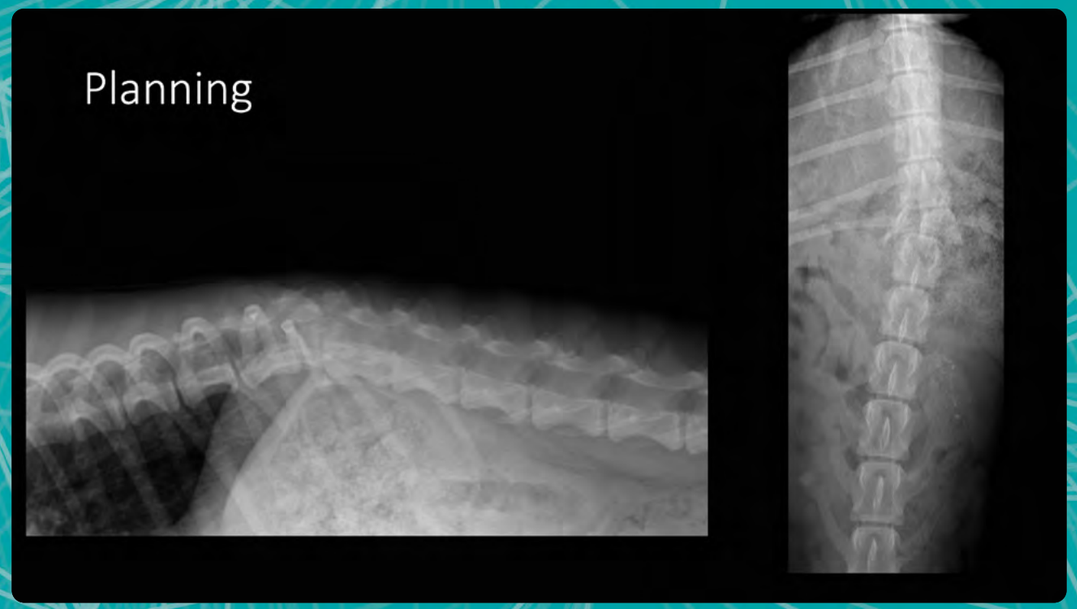

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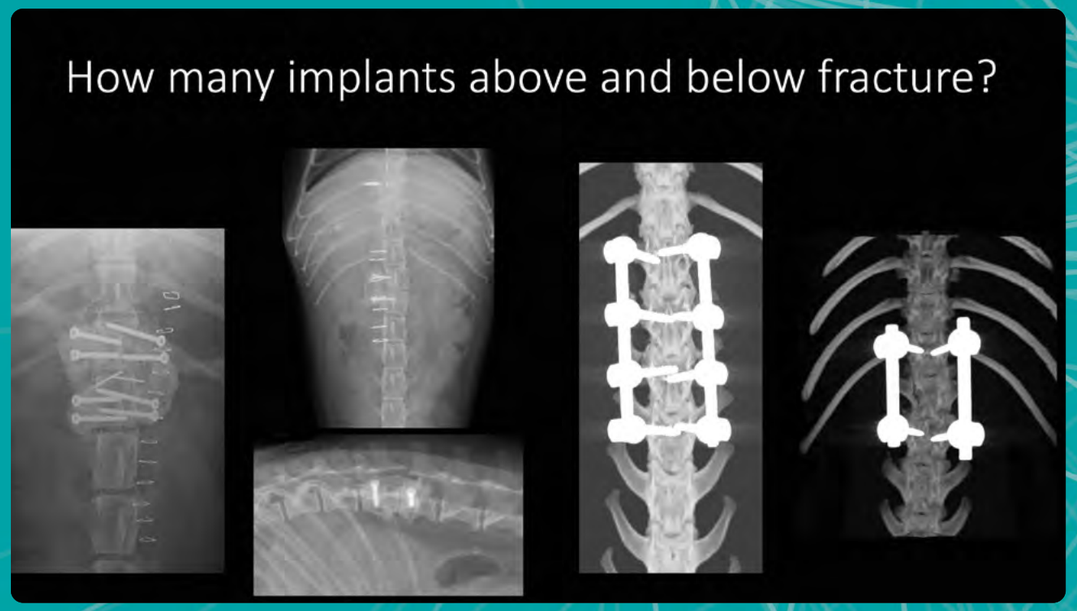
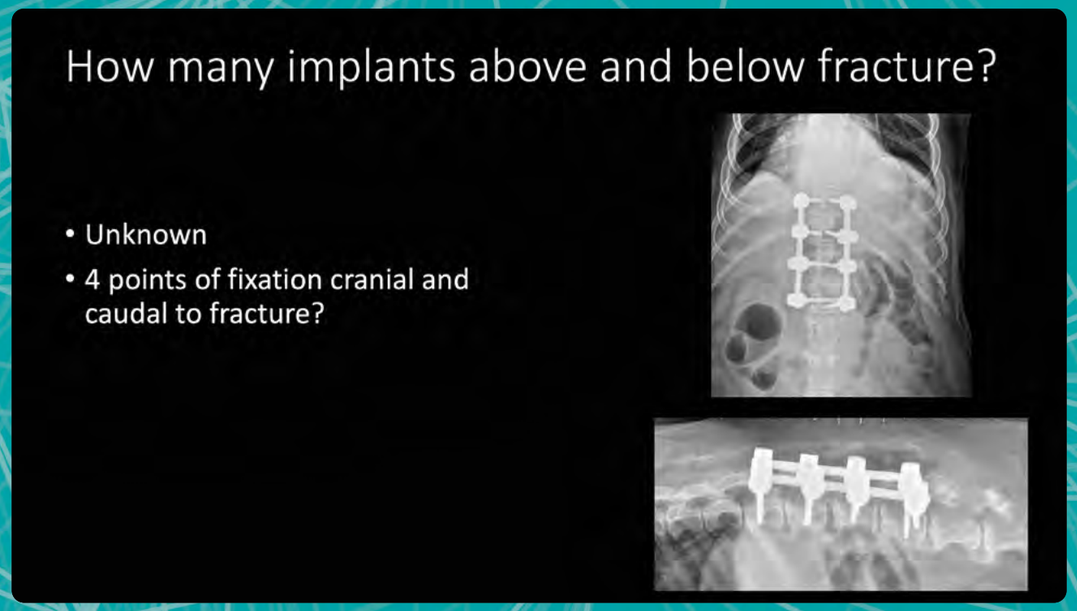

How many implants above and below fracture?


How many implants above and below fracture?
• Unknown
• 4 points of fixation cranial and caudal to fracture?

Notes

Notes

Implant Size

- Pedicle Screw Size
  - Size of implant – 20-50% diameter of bone
    - Roughly diameter of vertebral body
  - Bar Size
    - 5.5 mm tulip and bar vs. 3.0 mm tulip and bar
    - Closure of surgery site

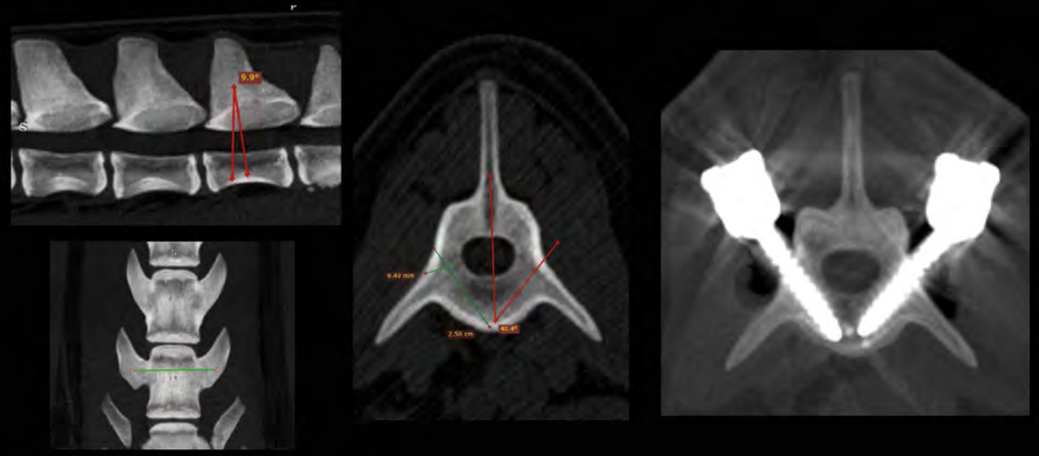
Pre-Operative Planning

- Variability depending on level of vertebral column
- Lumbar vertebrae have flatter angle of insertion
- Thoracic vertebrae have steeper angle of insertion

Notes

Notes

Planning: Example L5



Positioning

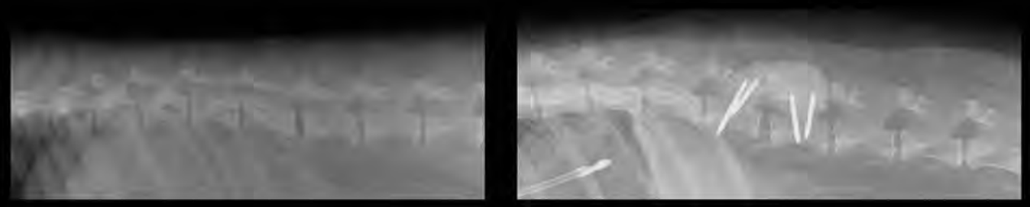
- Positioning on surgery table is important to aid in reducing the fracture or luxation
- Vertebral column should be in slightly kyphotic position
- Carefully placed towels or sandbags accomplish this

Notes

Notes

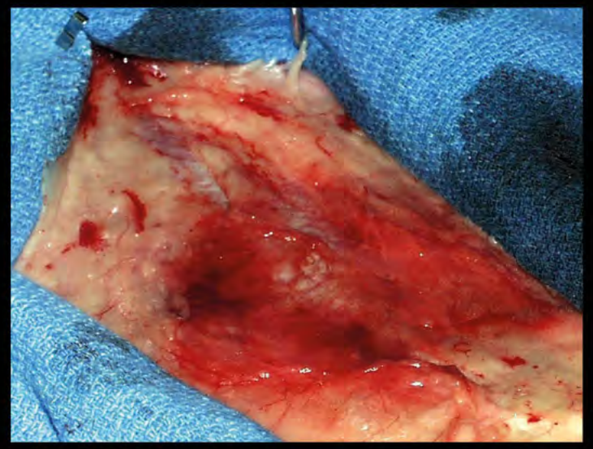
Positioning

- Poor Positioning Can Result in Lordosis
  - With an unstable vertebral column positioning impacts final stabilization
- Towel – can reduce to some degree with positioning



This dog was placed on the table without towels under the abdomen

Surgical Approach and Exposure

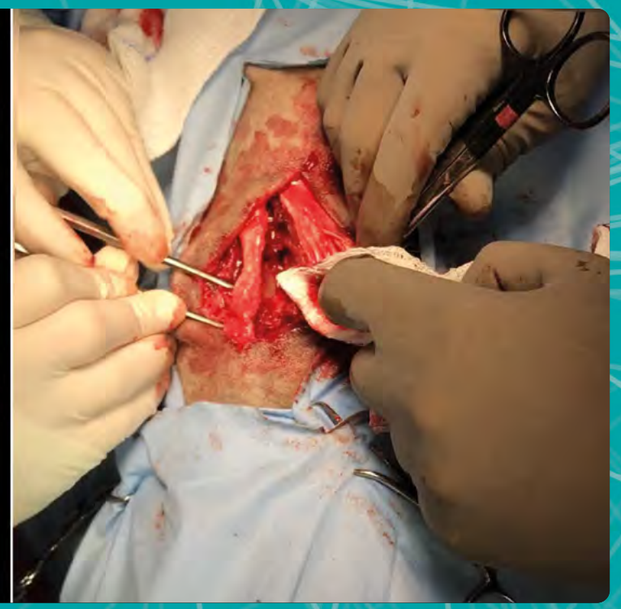


Notes

Notes

Approach

- Preserve ligaments if possible
  - Supraspinous ligament
  - Interspinous ligament
  - If dorsal laminectomy planned remove ligaments



Approach and Exposure

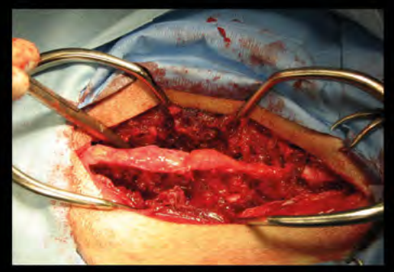
- Remove tendonous attachments of the spinal muscles from articular facets

Notes

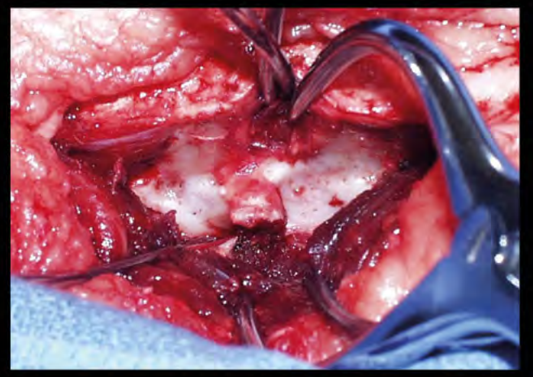
Notes

Approach

- Remove tendinous attachments from facets at site of fracture and 1 cranial and 1 caudal
- Place gelpis



Approach: Use of Gelpis but position properly



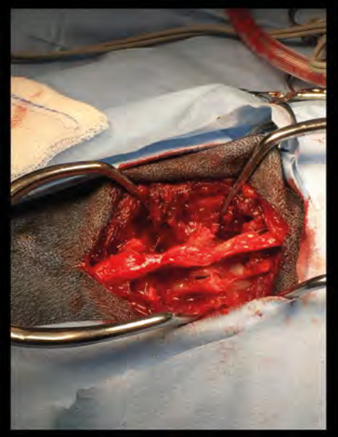
Gelpis placed improperly resulting curvature of spine after fixation

Notes

Notes

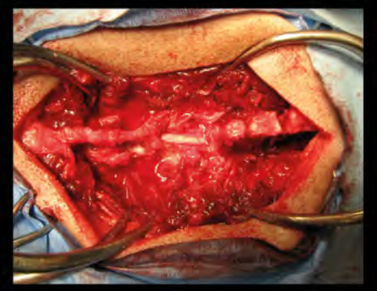
Approach

- Use of Gelpis
- Place on both sides of spinous processes to avoid scoliosis



Dorsal Laminectomy

- If decompression needed
  - Bone fragments
  - Hemorrhage
- Allows additional visualization when implants placed
- May not be needed

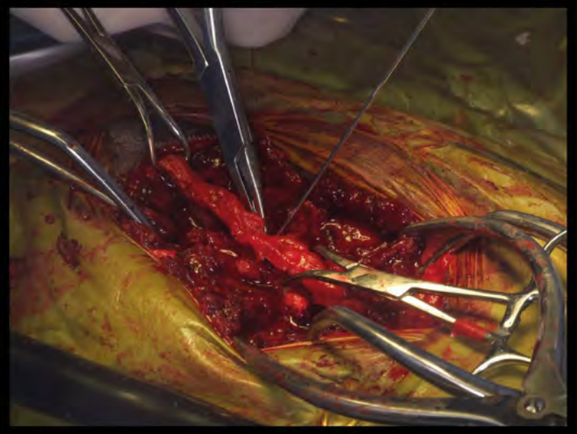


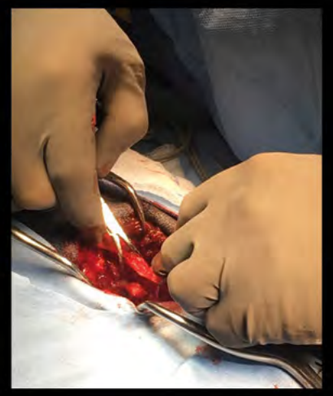
Notes

Notes

Reduction

- Use large towel clamps at base of spinous process





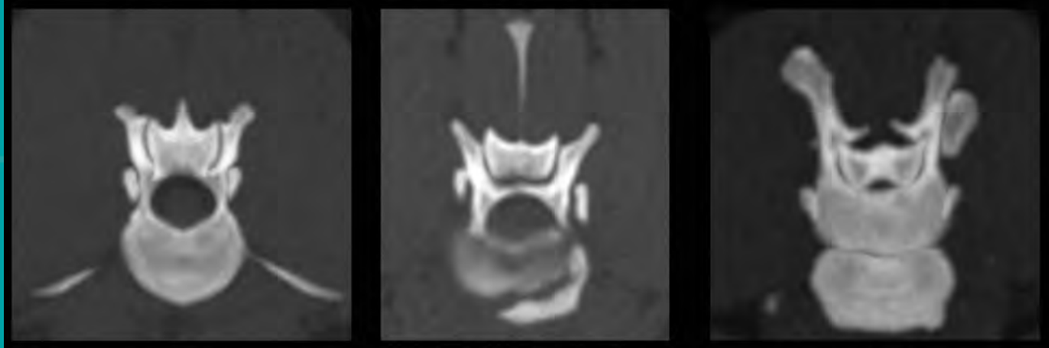
Facets Can Be Used To Maintain Reduction

- K wire
- Size
- Placement

Notes

Notes

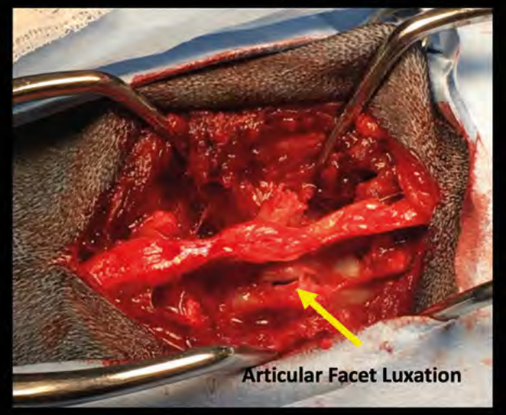
Variations of Facet Luxation



Normal | Mild Displacement | Severe Displacement

Expose Joint of Articular Facets

- Helps visualize anatomic reduction for accurate pin placement



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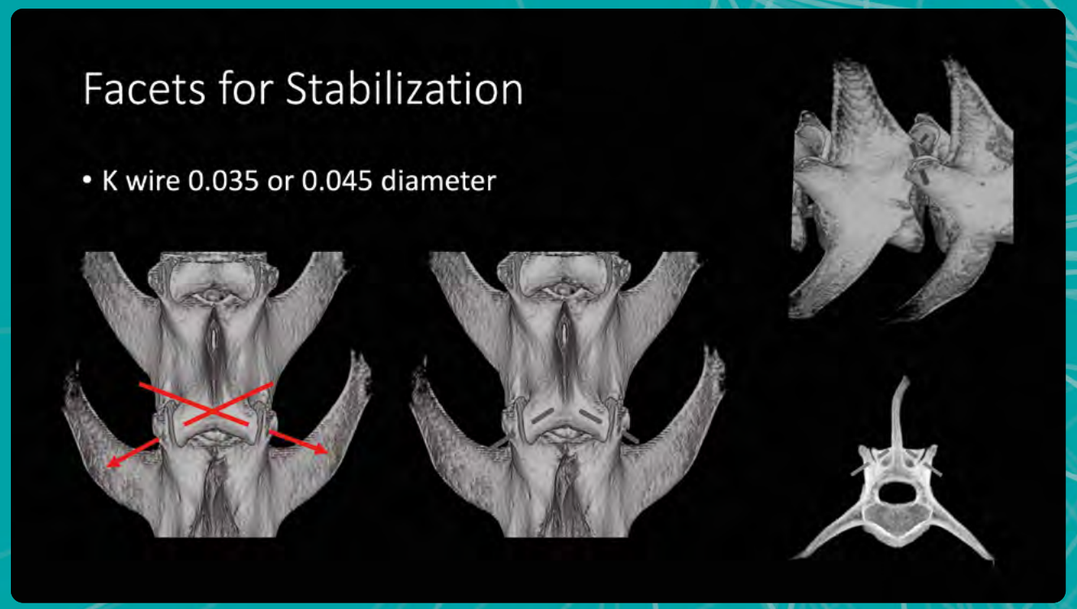

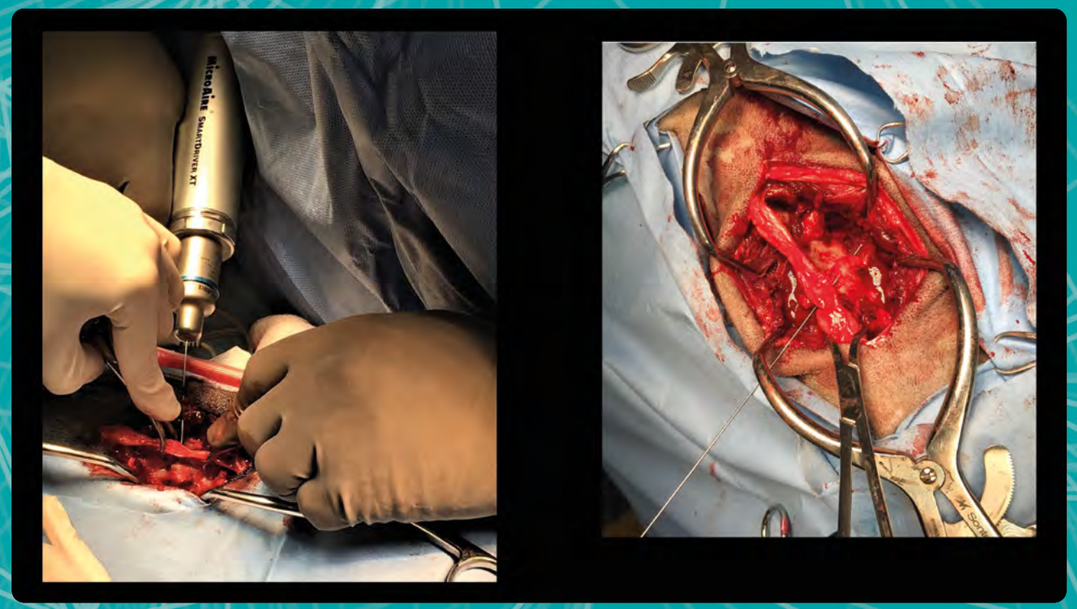

Notes

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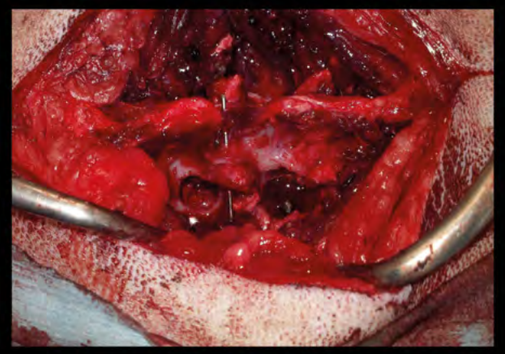
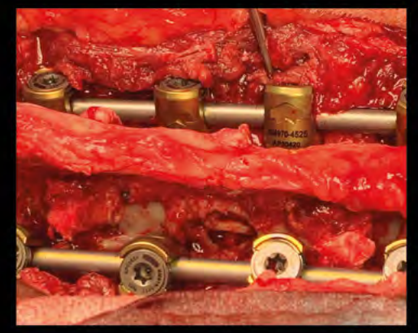
Facets for Stabilization



Visualize Spinal Cord: Keyhole



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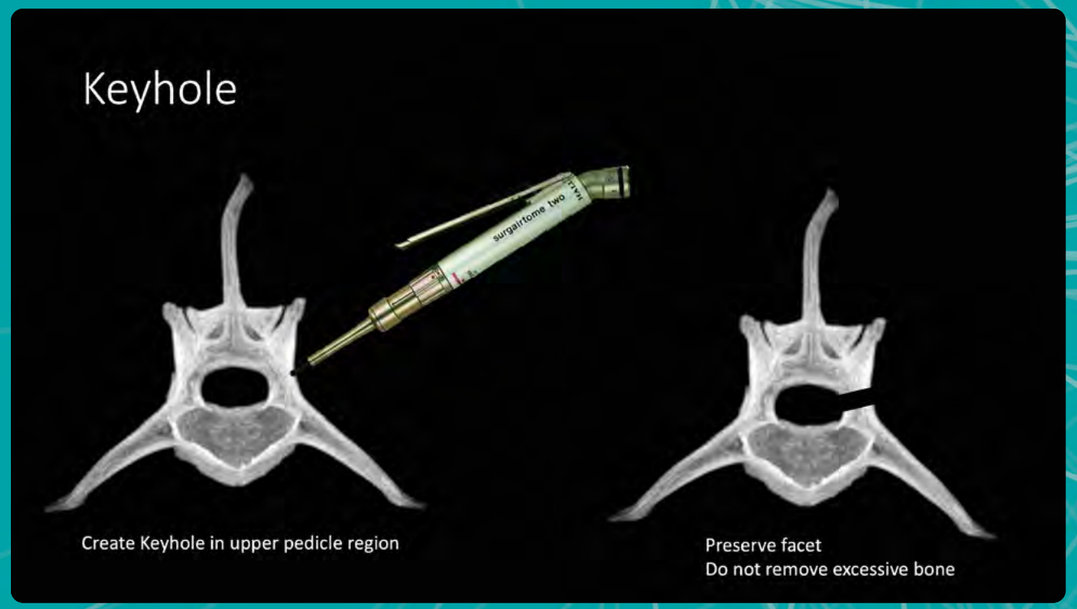
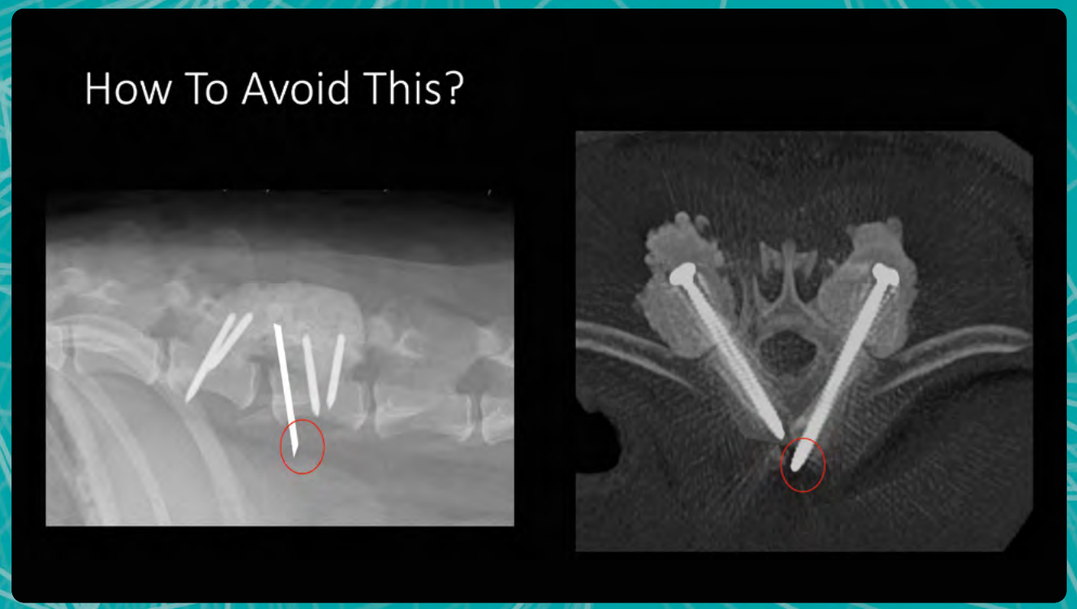

Keyhole
surgairtome two
Create Keyhole in upper pedicle region
Preserve facet
Do not remove excessive bone


How To Avoid This?

Notes

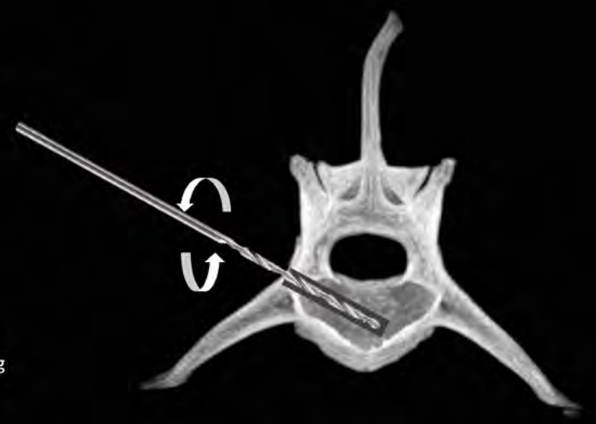
Notes

Implant Placement

- Measure Angle
- Drill
- Evaluate for breach
- Use depth gauge
- Mark implant
- Place screw

Drill

Burr small hole in cortex prior to drilling



Notes

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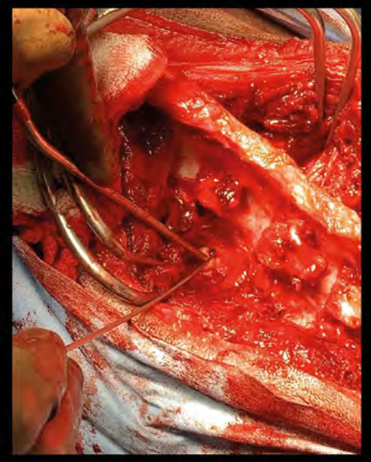
Depth of Pedicle Screw

- Leave enough of screw to allow full range of motion of the tulip

Probe for Breach and Place Screw



Notes

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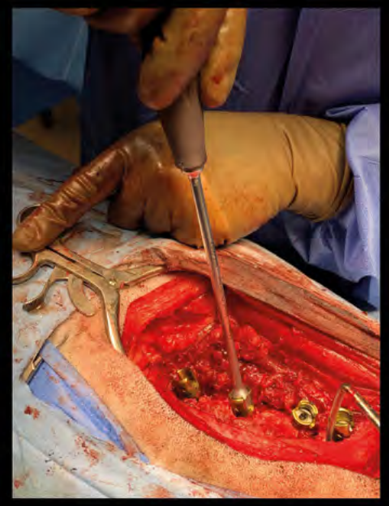
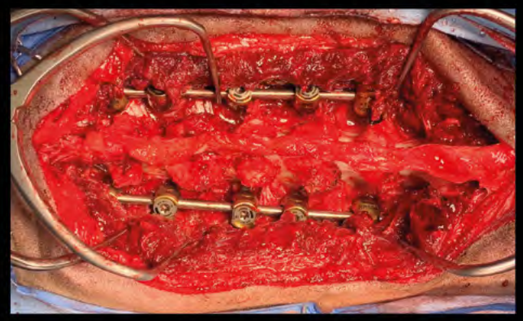
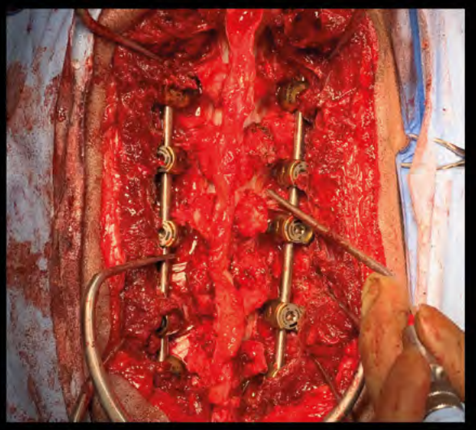
Position Tulips

- Use head positioner to place tulips in desired position to accommodate bar



Place Bars and Caps





Notes

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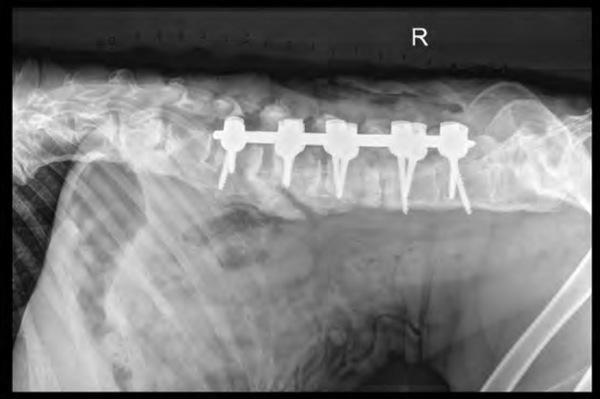
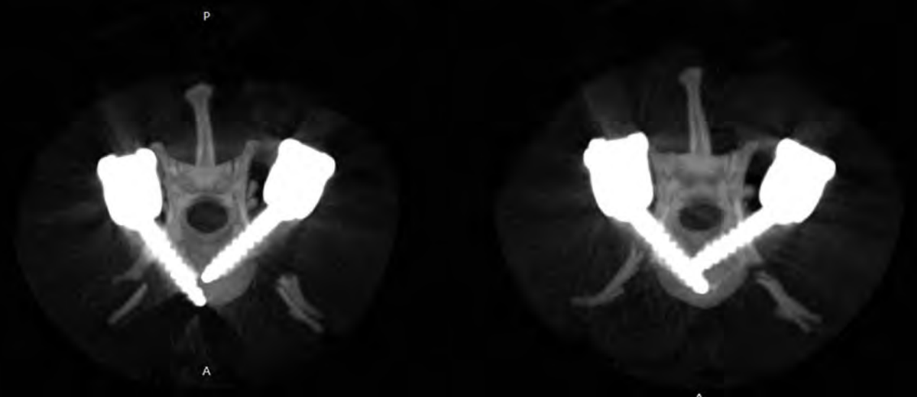
Post Operative Imaging



Post Operative Imaging: Recommend CT



Notes

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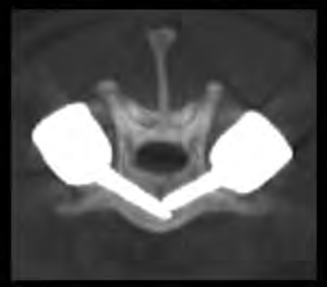
Complications

- Implant Malposition
- Implant Failure
- Infection



Summary

- Pedicle Screw Fixation Systems offer versatile method of thoracolumbar spinal fixation
- Pre-operative planning used for successful implant placement
- Post-operative imaging confirms proper implant placement

Notes

Notes

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