Hip Fracture Fixation With Nails
Thoughts, Techniques and Tips

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COI Disclosure

ZimmerBiomet: Consultant, Inventor, Trauma, ETEX, Knee Creations

Smith & Nephew, Nails and Plates, Memphis, TN

Intellectual Property Contracts

Textbook Contracts: Hip Fractures: Techniques in Orthopaedic Surgery 2nd Ed, Lippincott Williams and Wilkins, Surgical Treatment of Orthopaedic Trauma 2nd Ed. Thieme Publishers, New York, Rockwood and Green's Fractures in Adults 8th Ed, Lippincott Williams and Wilkins.

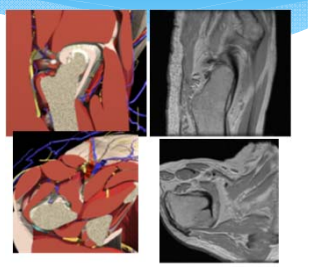
Next 20 Years
What We Will Learn

- **How To Differentiate Fractures**
- **How To Reduce Fractures**
- **How To Functionally Stabilize Fractures**
- **How to Monitor Fracture Healing**
- **How To Optimize Patient Recovery**

The Proximal Femur Is NOT as Solid As We Think

Medullary Canal Begins
Below Lesser Trochanter in Young Patients
Above Lesser Trochanter in Old

With Nail Techniques, A Path
Must Be Created Through
This Cancellous Bone



The Proximal Femur IS NOT A Solid Structure

- Subtrochanteric
- Pertrochanteric
- Femoral Neck

Harty,M. The Calcar Femorale* and The Femoral Neck. JBJS 1957
Garden. Structure and Function of The Proximal Femur JBJS 43B 1961
*Adam's Arch: Bartonicek

Four Major Components
Horizontal and Vertical Columns
Femoral Head and Shaft

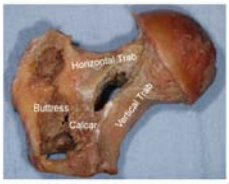


Fig. 7. Position of the calcar and its attachments to the vertical and horizontal

The structure of the femoral neck: A physical dissection with emphasis on the internal trabecular system

Narrowing of Antero-Superior Column With Age & Osteoporosis

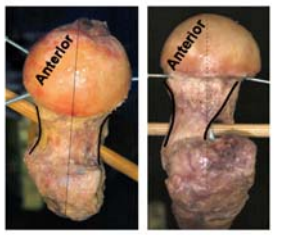


Fig. 8. Anterior 'shift' of the mass of the upper horizontal trabeculae with increasing osteoporosis. The wooden rod demonstrates the orientation of the 'neutral layer' with respect to the axis of the femoral neck.

Modern Failure Model UniCortical Single Screw Permits Rotation

Rotation Combined With Sliding=Bone Erosion

↓

Instability

↓

Collapse

↓

Distortion of Hip Mechanics

↓

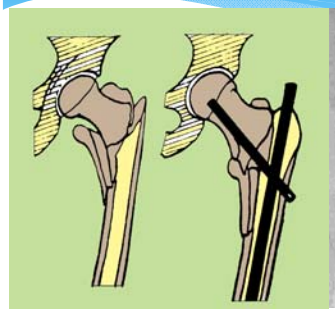
Pain, Disability and Death

Cephalomedullary Nail Constructs

Y-Nail Class	Gamma Class	Reconstruction Class	InterTan Class
(Impaction)	(Dynamic Compression) Single Large Lag Screw Large Head Nail	(Dynamic Compression) Two Lag Screws Small Head Nail	(Linear Compression) Two Integrated Screws Trapezoid Nail
Küntscher Y-Nail TFN (Synthes)	Gamma Nail (Stryker-Howmedica) IMHS (Smith&Nephew)	Reconstruction Nail (Smith&Nephew) TFN (Synthes)	InterTan Nail (Smith&Nephew)

Russell Classification
Rockwood &Green 2010

Küntscher/Pohl Y-Nail 1940's



2001 Impaction Type Nails

Impaction Nails
Insert Tip >10mm from Joint

Watch Out For Medial Perforation

JOT 2008, Vol 22(10) Nov/Dez 2008, 731-6

Gill JJ, Allchin, P.C; Rafiei, P; Reddy, K; Schutt, R C, Jr. Intertrochanteric hip fractures treated with the trochanteric fixation nail and sliding hip screw. *J Surg Orthop Adv.* Summer 2007;16(2):62-66.

Courtesy Dr. Buecker

Functional And Radiographic Outcomes Of Intertrochanteric Hip Fractures Treated With Calcar Reduction, Compression, and Trochanteric Entry Nailing

Paul O; Barker JU; Lane JM; Helfet DL; Lorich DG

J Orthop Trauma 2012 Mar;26(3):148-54

* 30 Patients Level IV Study.
* CONCLUSIONS: Satisfactory Functional Outcomes With Near-normal Gait Restoration Can Be Achieved In Cases Of **Intertrochanteric Hip Fractures** With An Emphasis On Calcar Reduction And Compression After Fixation With Trochanteric Entry **Nail**.

Gamma Nail Class 1, 2, 3
1986-2011 Grosse & Kempf

- 1980's: Gamma Nail 10 Degree Proximal Bend Lat Port
  - Drs. Arsène Grosse & Ivan Kempf
- Initially for Pertrochanteric Fractures
- Subsequent Design Changes G3 Newest

A. Grosse

I. Kempf

13

Reconstruction Nail Class
Russell, Taylor and Brumfeld 1985

Reconstruction Nails: (Double Lag Screw)

First Integral Variable Section Modulus Cannulated Intramedullary Stainless Steel Nails

Smaller Head Diameter

Primary Indication Subtrochanteric Hip Fracture

14

Nov-16

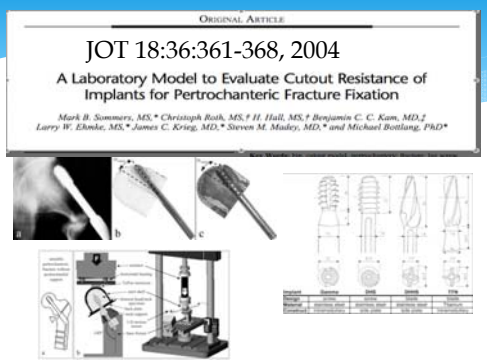
2004 InterTan Class

Russell, Sanders, Grusin, Faber, Mimes, Ferrante

Designed to Increase Hip Fracture Stability
Trapezoidal Cross Section
Integrated Proximal Compression Screws
Flat Lateral Side to Relieve Trochanteric Stress
5 Degree Lateral Bend
Short and Long

Smith & Nephew, Memphis

Rotational Instability Leads To Cut-Out


ORIGINAL ARTICLE

JOT 18:36:361-368, 2004

A Laboratory Model to Evaluate Cutout Resistance of Implants for Pertrochanteric Fracture Fixation

Mark B. Sommers, MS,* Christoph Roth, MS,† H. Hall, MS,† Benjamin C. C. Kam, MD,‡ Larry W. Ehmke, MS,* James C. Krieg, MD,* Steven M. Madey, MD,* and Michael Bottlang, PhD*

Single Screw Instability

- Varus Collapse 8.5+/-7.7 Degrees
- Rotation 7.2+/-6.4 Degrees

- Clinically Realistic Multiplanar Loading Vectors Significantly Affects Implant Migration, And Therefore Should Be Considered When Evaluating The Fixation Strength Of Hip Screw Implants.

Ehmke, L.W., et al., Lag screws for hip fracture fixation: Evaluation of migration resistance under simulated walking. J Orthop Res, 2005. 23(6): p. 1329-35.

KU LEUVEN

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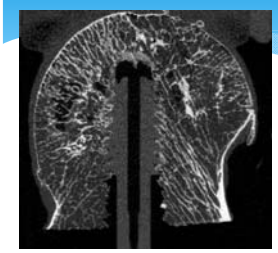
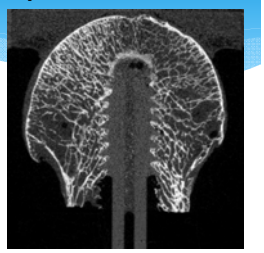
Visualization of implant failure



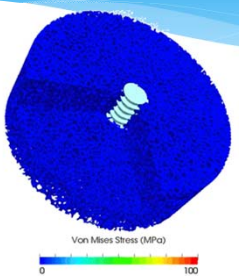
low bone mass:
direct failure at the interface



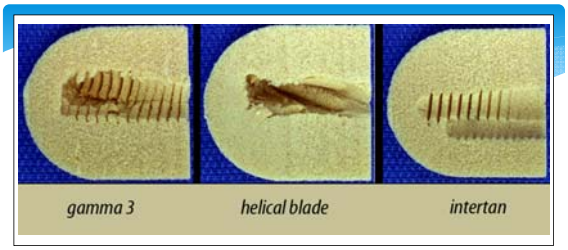
high bone mass:
support of peri-implant bone

Mueller et al. (2013). *MedEngPhys*, http://dx.doi.org/10.1016/j.medengphy.2012.07.009.

Computational Analyses Of Implant Failure



Courtesy: Harry van Lenthe, KU Leuven



	SINGLE LAG SCREW	HELICAL BLADE	INTERTAN
SAMPLE 1	4100	9500	DID NOT CUT OUT
SAMPLE 2	28900	52000	DID NOT CUT OUT
SAMPLE 3	12700	17800	DID NOT CUT OUT
AVERAGE	15233	26433	N/A
STD. DEV.	12593	22527	N/A

ORS Russell et al 2010

Construct Testing
Femoral Head Rotation and Varus Collapse
Single Vs Integrated Screws

- Santoni, Brandon G. PhD; Nayak, Aniruddh N. MS; Cooper, Seth A. MD; Smithson, Ian R. MD; Cox, Jacob L. MD; Marberry, Scott T. MD; Sanders, Roy W. MD
- Comparison of Femoral Head Rotation and Varus Collapse Between a Single Lag Screw and Integrated Dual Screw Intertrochanteric Hip Fracture Fixation Device Using a Cadaveric Hemi-Pelvis Biomechanical Model
- Journal of Orthopaedic Trauma:
- April 2016 - Volume 30 - Issue 4 - p 164–169

Surgical Technique
New Directions

1. Fracture Visualization
2. Entry Portal
3. Trajectory Control Of Reamers/Nail
4. Implant Matching
5. Implant Stability

Classic Supine Position
Leg Positioning

- Flexion 0-40 Degrees
  - 31-IT-0-15 Degrees
  - 31-ST-30-40 Degrees
  - 32 FS 10-30 Degrees
  - 33 SC 0 Degrees
- Adduction 0-20 Degrees
- Rotation 0-+15 Degrees

Bad Set Up:
C-Arm Wrong Axis
Distal Fragment Flexed
Leg Extended

Classic Lateral Position

- Hip Flexion 30-40 Degrees
- Adduction -10-0-+10
- Rotation
  - 15 -30 Degree Internal Rotation Of Foot
- Best For Short Proximal Fragments And Reverse Obliquity Pattern
- OTA/AO A3 Types

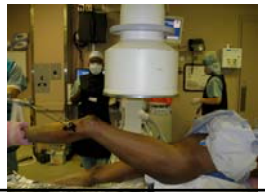
Supine Positioning

- Supine

Flex Leg 30-40 Degrees
Abduction 0 Degrees
Rotation 0-15 Degrees ER
Position C-Arm In Reference To Hip
Not Ideal For Piriformis Portal
Trochanteric Portal More Efficient

Pertrochanteric Operative Pearls

- Exposure
  Radiographic Visualization in Correct Plane
- Place C-Arm Beam Perpendicular to Femur



Pertrochanteric Operative Pearls

- Exposure
  Radiographic Visualization in Correct Plane
- First Fix AP Alignment

Pertrochanteric Operative Pearls

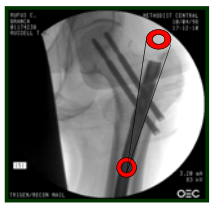
Radiographic Visualization in Correct Plane

- Second Fix Rotational Alignment

15 Up and 15 Over

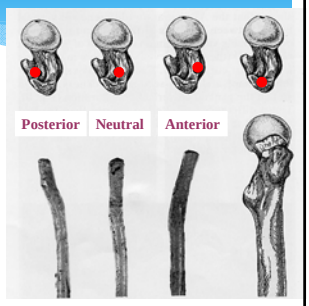
Femoral Entry Portal

- Medial-Lateral Position
- Piriformis Portal
  - Straight Nails
- Trochanteric Portal
  - 4-10 Degree Proximal Angulation
  - Lateral Trochanteric Portal Problem
  - Tip to Medial Trochanteric Portal



Importance of Entry Site

- Nail entry site dictates the ultimate placement of the implant
- Starting points are made in reference to the neutral axis:
  - Anterior vs. Posterior
  - Medial vs. Lateral
  - Piriformis vs. Trochanteric



T.A.Russell

Johnson *et al.*, *J. Ortho. Trauma*, 1(1):1-11, 1987

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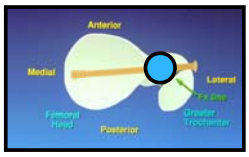
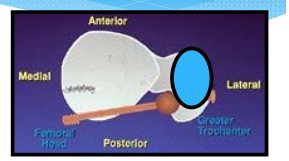
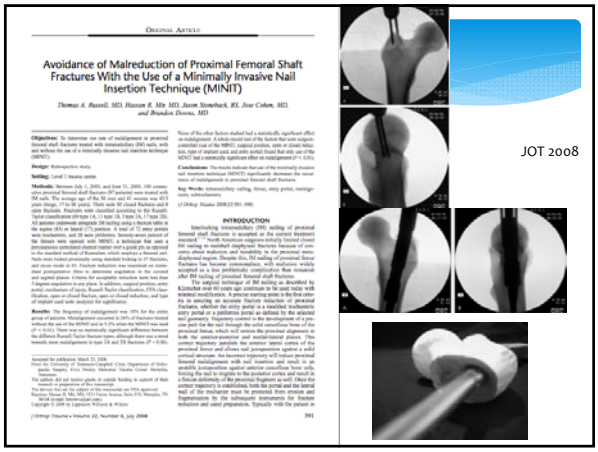
Nail Containment In Proximal Femur





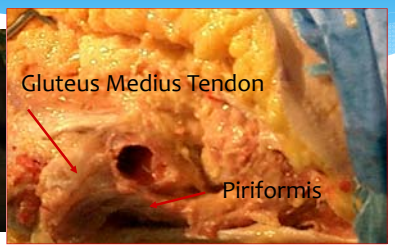
Reamer Damaged Portal



Avoidance of Malreduction of Proximal Femoral Shaft Fractures With the Use of a Minimally Invasive Nail Insertion Technique (MINIT)

JOT 2008

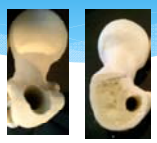
Medial Trochanteric Entry Precision Portal Placement



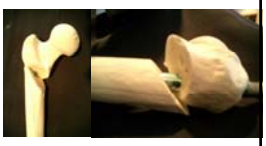
Perez, Juhangir, Russell JOT 2008

Trajectory Control Portal Protection

Good



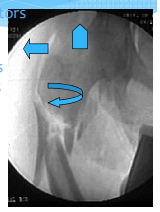
Bad



T.A.Russell 35 2010

Reduction Technique

* Hibbs: 1900's 90-90 Traction
  * Proximal Fragment Flexes, Abducts and Externally Rotates
  * **Bring Distal Fragment To Proximal Fragment**



1963 Reduction
The Key To Success

- Sarmiento ,"Weight-bearing on the fractured extremity is safe only if the fracture, whether simple or comminuted, has been reduced so that there is an accurate fit of the fragments at the anteromedial cortex of the femur.
- Failure to obtain such reduction because of the degree of comminution or technical difficulties precludes weight-bearing until bone union is complete.
- Anatomical reduction of the medial and anterior cortices is of great importance since the stability of the fracture and the efficiency of the nail depend on the reduction of this portion of the bone"

Sarmiento, A. Intertrochanteric Hip Fractures. JBJS 1963;45(4): 706-722

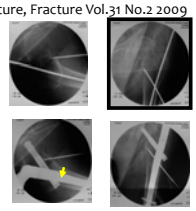
Anteromedial Reduction

Carr JB. The Anterior and Medial Reduction of Intertrochanteric Fractures: A Simple Method to Obtain a Stable Reduction. *Journal of Orthopaedic Trauma.* 2007;21(7):485-489

Satoru Ookuma, Fumio Fukuda, et al.: The relationship of reduction and telescope in the stable 2 part femoral trochanter fracture, Fracture Vol.31 No.2 2009

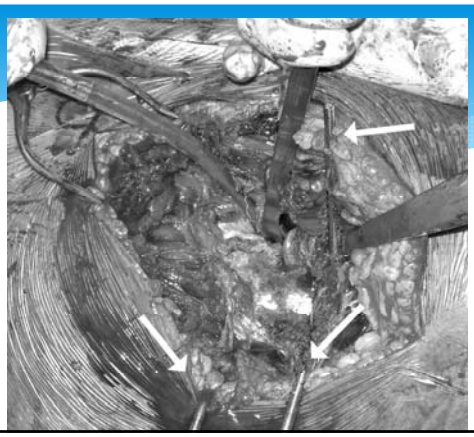
3

Reduction Method



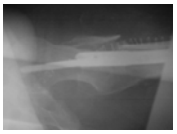
Open Reduction
Always An Option

- Watson-Jones Approach
- Key Deep Interval Is Origin Of Vastus Lateralis Muscle: Optimal Place For Cerclage Wire Or Clamp



Lateral Shaft Alignment

Nail Follows Path Of Reamer On Lateral Radiograph



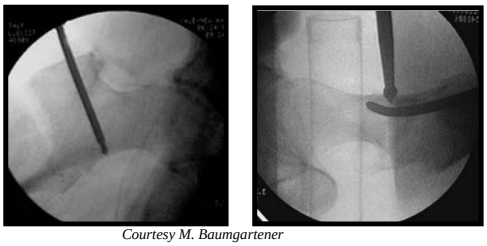
Reamer Trajectory In Proximal Fragment Dictates Reduction

Reduction Maneuvers

- Fracture Table Manipulation
- Percutaneous Reduction
- TriGen Reducer
- F Wrench (H.O.Thomas Wrench: Liverpool)
- Femoral Distractor
- Open Reduction

Reduction Tactics
Percutaneous Reduction

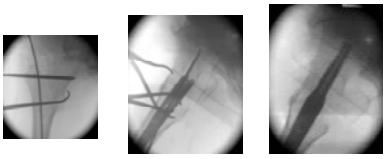
External Fixation Pin and Ball Spike Pusher
Reduces Flexion And External Rotation Proximal Segment



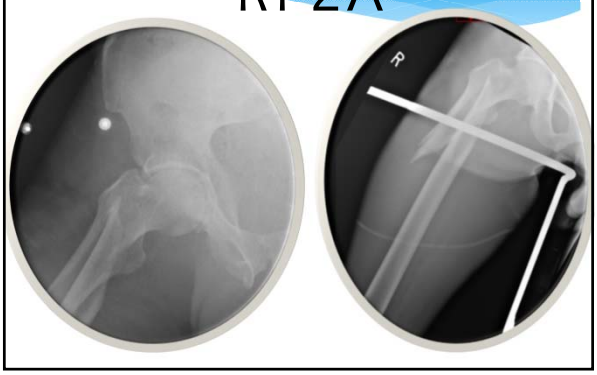
Courtesy M. Baumgartener

Pertrochanteric Operative Pearls

- Reduction
  - No Varus
  - Approximate Anterior Cortex At Fracture Site
  - Open or Percutaneous Joy Sticks As Needed
  - Wire Cerclage?



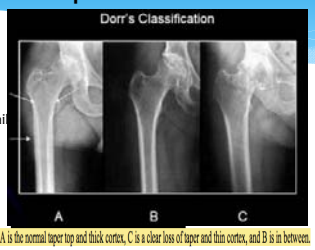
RT 2A



Cerclage TAN Recon

Femoral Morphology Implant Selection

Young
Small Diameter Nail
Plate



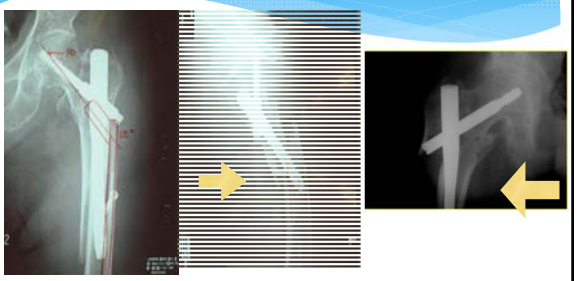
A is the normal taper top and thick cortex, C is a clear loss of taper and thin cortex, and B is in between.

Older Age
Large Nail
Long
Stable Plate?

Middle Age
Plate or Short Nail

1. Dorr LD, Faugere MC, Mackel AM, et al. Structural and cellular assessment of bone quality of proximal femur. *Bone. 1993; 3:231-242.*

Peri-Implant Failures Translational Nail Instability

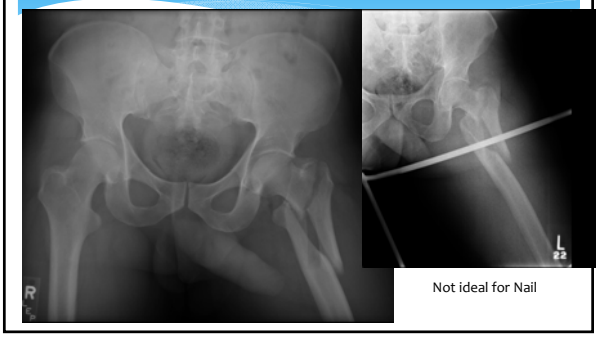


Long Vs. Short Nail

- No Difference in Incidence of Peri-implant Failure With Short Compared to Long Nail ≤1%
- Distal Locking Decreases Risk
- Unlocked Nails Risk Increases to 10% at 5 Years
- Cost of Implants Equivalent

Short Versus Long Cephalomedullary Nails for the Treatment of Intertrochanteric Hip Fractures in Patients Older than 65 Years. Kleweno et al JOT 2014
Boone C, Carlberg KN, Koueiter DM, et al. Short versus long intra- medullary nails for treatment of intertrochanteric femur fractures (OTA 31-A1, A2). JOT. 2014
Short Versus Long Intramedullary Nails in the Treatment of Pertrochanteric Hip Fractures: Incidence of Ipsilateral Fracture and Costs Associated With Each Implant. Lindvall et alJOT 2016
Hou Z et al. Treatment of pertrochanteric fractures (OTA 31-A1 and A2): long versus short cephalomedullary nailing. JOT 2

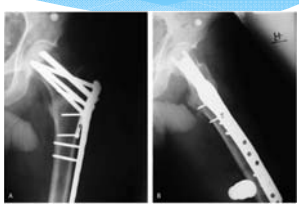
Unstable Proximal Femur Nail Containment Difficult



Not ideal for Nail

Proximal Locked Plate For Highly Unstable Fractures

The Lateral Decubitus Approach for Complex Proximal Femur Fractures: Anatomic Reduction and Locking Plate Neutralization: A Technical Trick



Connelly and Archdeacon JOT 2012

Streublel et al JOT 2012 37% Failure Rate In A3 Fx 3 Screw Synthes PFP

Future of Implant Design

- Better Appreciate The Complexity of the Femur
- Reduction and Implant Stability Improvements
- Decrease Pain and Improve Early Functional Recovery
- Augmentation of Optimized Nail Designs