

## Femoral Neck Fractures in Young Adults: *What is the Standard?*

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### We accept....



- Femoral neck fracture in young adults
- Difficult injuries
  - Early, skilled treatment essential
  - Complications are potentially catastrophic
  - Salvage Rx are common

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### This Lecture



- Describe injury pattern
- What is the standard?
- Optimal care
- Expectations



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## Early Surgical Rx



Protzman and Burkhalter. Femoral neck fractures in young adults. JBJS-Am, 1976.

- 22 patients aged 20-40 (Army)
- Mostly CRIF

- 59% nonunions
- 86% AVN




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## Who Risks Failure?



What is likely to affect union?

- Host factors (hormones, smoking, etc....)
- Intra-articular injury (synovial fluid)
- Vascularity
- Fracture configuration

- Reduction
- Fixation

Affected by surgeon

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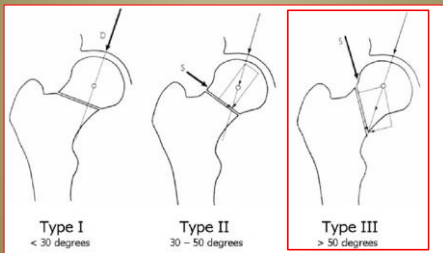
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## Who Risks Failure?



- Fracture orientation: vertical




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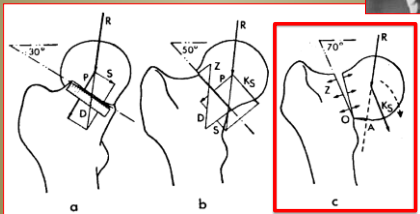
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# Friedrich Pauwels (1920's)



- Biomechanical view of hip fractures
- Compressive vs. shearing forces




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# Modern Treatment



Liporace et al. Results of internal fixation of Pauwels' III vertical femoral neck fractures. JBJS-Am, 2008.

- 56 patients young patients with Pauwels' III
- Mostly CRIF

- 17% nonunion  
 - 12% AVN  
 } 30% failure rate




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# Modern Treatment



- I have failed




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## Modern Treatment

- Failure is costly for the young patient

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## Modern Treatment

- Ignored injury
- Swiontkowski et al.
- .....
- .....
- .....
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- .....
- ?



**MEDIOCRITY**  
Set the bar low enough and everyone is exceptional.

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## Outcomes

Zielinski et al. Femoral Neck Shortening After Internal Fixation of a Femoral Neck Fracture. Orthopedics, 2013; 36(7) 138-147.

- Results "IF of femoral neck fractures and femoral neck shortening affect patient VAS scores and functional outcomes."

Variable	Total (N=76)	Little or No FNS <sup>a</sup> (n=25)	Moderate FNS <sup>b</sup> (n=26)	Severe FNS <sup>c</sup> (n=25)	P
Femoral neck shortening, cm <sup>d</sup>	1.1 (0.5 to 1.7)	0.4 (0.1 to 0.5)	1.1 (0.9 to 1.3)	2.0 (1.7 to 2.3)	<.001
Feeling of LLP <sup>e</sup>	31 (40.6)	5 (20.0)	7 (26.9)	19 (76.0)	<.001
VAS score complaints of LLP <sup>f</sup>	4.0 (1.3 to 7.2)	2.3 (0.3 to 7.1)	4.9 (4.0 to 8.0)	3.9 (1.9 to 7.0)	.242
Fused hip use <sup>g</sup>	23 (30.3)	3 (12.0)	4 (15.4)	16 (64.0)	<.001
VAS score satisfaction with gait pattern <sup>h</sup>	7.5 (5.1 to 8.7)	8.0 (6.5 to 9.0)	7.3 (5.3 to 8.3)	7.3 (4.3 to 8.0)	.006
SF-12 score <sup>i</sup>	102.1 (92.3 to 108.0)	102.4 (90.3 to 108.0)	101.7 (92.9 to 106.2)	99.8 (83.9 to 108.2)	.439
WOMAC score <sup>j</sup>	86.5 (72.9 to 97.4)	95.6 (80.2 to 99.0)	88.5 (73.8 to 97.9)	81.2 (58.9 to 92.4)	.059
Foot axis, deg <sup>k</sup>	0.5 (-3.5 to 4.6)	2.4 (-1.2 to 7.4)	-2.0 (-7.3 to 3.9)	-1.8 (-6.5 to 4.6)	.034

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# Outcomes



Zielinski et al. Femoral Neck Shortening After Internal Fixation of a Femoral Neck Fracture. Orthopedics, 2013; 36(7) 138-147.

- Results

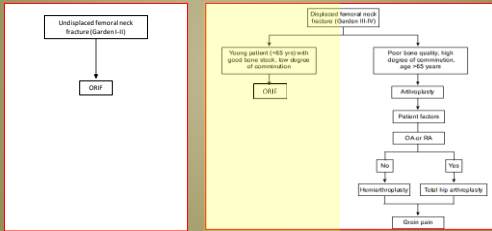
“Displaced fractures and Pauwels 3 fractures shorten the most.”

Patient and Fracture Characteristics					
Characteristic	Total (n=74)	Little or No FNS <sup>a</sup> (n=22)	Moderate FNS <sup>b</sup> (n=26)	Severe FNS <sup>c</sup> (n=22)	P
Age, y <sup>d</sup>	68.3 (63.6-76.4)	70.5 (62.4-79.3)	69.4 (63.7-77.2)	67.1 (60.6-78.7)	.802
Male sex <sup>e</sup>	37 (48.7)	8 (32.0)	11 (42.3)	18 (72.0)	.413
Weight, kg <sup>f</sup>	75.0 (63.0-83.0)	65.0 (56.5-76.5)	72.5 (62.3-83.0)	80.0 (71.5-90.0)	.003
BMI, kg/m <sup>2</sup>	24.3 (21.9-26.0)	23.6 (21.1-25.3)	24.0 (21.4-25.3)	25.0 (23.5-28.4)	.021
ASA score >2 <sup>g</sup>	5 (6.6)	1 (4.0)	1 (3.8)	3 (12.0)	.465
Institutionalized prefracture <sup>h</sup>	1 (1.3)	0 (0.0)	0 (0.0)	1 (4.0)	.356
Prefracture use of aids <sup>i</sup>	6 (7.9)	1 (4.0)	2 (7.7)	3 (12.0)	.576
Displaced fracture (Garden III-IV) <sup>j</sup>	50 (67.6)	13 (59.1)	17 (65.4)	20 (90.9)	.006
Pauwels class I <sup>k</sup>	27 (35.5)	3 (12.0)	11 (42.3)	13 (52.0)	.009
Pauwels class II <sup>l</sup>	22 (28.9)	1 (4.0)	7 (26.9)	14 (56.0)	.001
Time FNS measurements since surgery, mo <sup>m</sup>	11.9 (11.2-12.4)	11.7 (11.3-12.3)	11.5 (10.5-12.3)	11.8 (11.2-12.6)	.416
Time gait measurements since surgery, mo <sup>n</sup>	22.3 (18.9-24.1)	22.9 (20.0-27.0)	22.0 (18.2-23.7)	21.5 (17.8-23.2)	.187

# Treatment Decisions



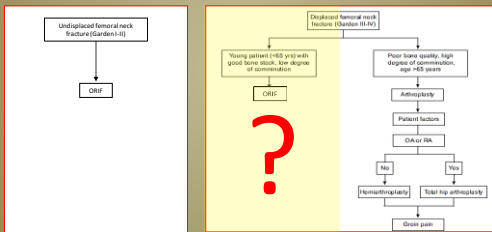
- Algorithms (e.g. MacCauley et al, JAAOS, 2006)



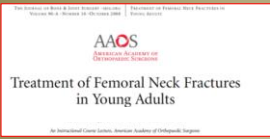
# Treatment Decisions



- Algorithms (e.g. MacCauley et al, JAAOS, 2006)



# Treatment Decisions



Treatment of Femoral Neck Fractures in Young Adults

- Algorithm provided

an axially loaded, high-energy force applied to an abducted hip) result in a basiscervical or more distal neck fracture. The fracture pattern has a tendency to be more vertically oriented and, thus, biomechanically more unstable<sup>14,15</sup>. These characteristics have important implications with regard to obtaining and maintaining stable fixation, both of which are necessary for healing to occur.

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# Treatment Decisions



Treatment of Femoral Neck Fractures in Young Adults

- Algorithm provided

imaging, a Weber clamp or 2.0-mm Kirschner wires can provisionally hold the reduction. Definitive fixation can be obtained with three cannulated or noncannulated cancellous screws (Fig. 3). Closure is routine. Another approach, with use of a modified Smith-Petersen sur... as been described<sup>16</sup>,... t access to and visualiza... ral neck fracture, esp... capital region. How... cision is required for...  
 ?  
 The postoperative regimen that

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# Treatment Decisions



- ICL Example



Fig. 4-A  
Figs. 4 A through 4 E A twenty-two-year-old man with a displaced right femoral neck fracture sus-

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# Treatment Decisions



Fig. 4-B Anteroposterior radiograph after open reduction and internal fixation with three cannulated cancellous screws. Fig. 4-C Lateral hip radiograph after open reduction and internal fixation.

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# Treatment Decisions



Fig. 4-D Anteroposterior radiograph made at eight months postoperatively. There is some settling of the fracture and a lack of complete healing at this point. The patient had no pain and was bearing full weight.

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# Treatment Decisions

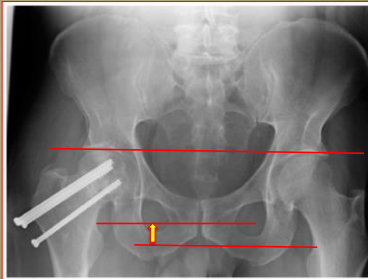


Fig. 4-D Anteroposterior radiograph made at eight months postoperatively. There is some settling of the fracture and a lack of complete healing at this point. The patient had no pain and was bearing full weight.

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## Treatment Decisions



- What might have been done differently?

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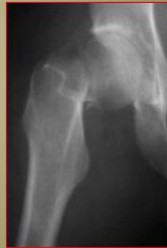
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## Treatment Decisions



- What about pre-operative planning?



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## Treatment Decisions



- Is evaluating this in surgery OK?



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## Treatment Decisions



**What sort of evaluation is being done?**

- 3 trauma centers
- 65 Pauwels' III vertical neck fractures in patients <50 yo undergoing repair
- Exclusion:
  - Acetabular or femoral shaft fx
  - Arthroplasty

Collinge, Beltran, Reddix, and Mir. J Ortho Trauma submitted

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## Treatment Decisions



**What sort of evaluation is being done?**

- "AP and "lateral" Xrays 65/65
  - Vertical pattern apparent 30/65 (55%)
- "Advanced" imaging
  - 2% had dynamic/ traction views
  - 55% had CT scan (25/30 trauma scans)

Collinge, Beltran, Reddix, and Mir. J Ortho Trauma submitted

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## Treatment Decisions



- Radiography: 52 yo rancher

Finding: Half went to OR with this radiographic work-up

Collinge, Beltran, Reddix, and Mir. J Ortho Trauma submitted

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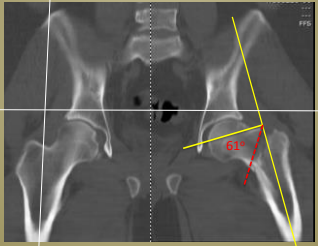
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### Fracture Morphology

- Confirmed vertical fracture



Collinge, Reddix, and Mir. J Ortho Trauma, April 2014

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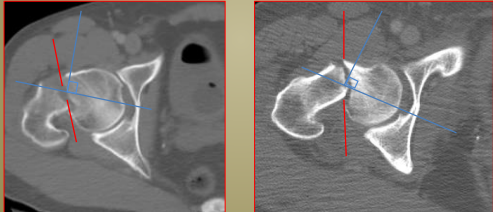
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### Fracture Morphology

- External rotation deformity
- Fracture rarely transverse



Collinge, Reddix, and Mir. J Ortho Trauma, April 2014

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### Fracture Morphology

- Comminution  
– Young 95%
- Apex inferiorly on calcar



Collinge, Reddix, and Mir. J Ortho Trauma, April 2014

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### Fracture Morphology

- Loss of the calcar buttress: 50%

Collinge, Reddix, and Miral Ortho Trauma, April 2014

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### Fracture Morphology

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### Fracture Morphology

So now what?

- Better idea of obtaining reduction
- Not everyone gets the same construct (?)
  - Buttress plating the neck?
  - Fixed angled devices with rotational control ?
- Modelling for Lab studies

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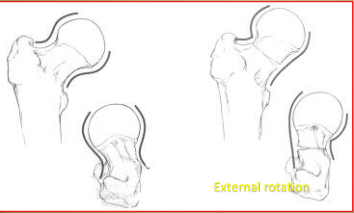
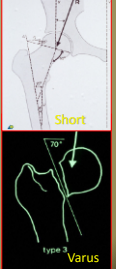
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## Reduction

- Must overcome *deformity* and *muscle forces*

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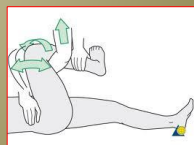
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## Reduction

- Leadbetter Technique
  - Flex the hip to 90°, slight adduction
  - In-line traction with the femur
  - While maintaining traction, IR to 45°
  - Slowly move into slight abduction and full extension, while maintaining traction and internal rotation
- Lots of others




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## Reduction

Karanicolas et al. Interobserver Reliability of Classification Systems to Rate the Quality of Femoral Neck Fracture Reduction. JBJS-Am 2004

- Assessed inter-rater reliability of surgeons using reduction grading systems
- Reviewed series of femoral neck ORIF's
- 5 scales used vs. "clinical impression"

e.g.

Quality of Reduction	Criteria
Acceptable	Anteroposterior alignment 160-175 degrees Lateral angulation ≤30 degrees
Unacceptable	Anteroposterior alignment <160 degrees or >175 degrees or lateral angulation >30 degrees

Quality of Reduction	Criteria
Excellent	Perfect anteroposterior and lateral alignment
Acceptable with minor concerns	<2-mm anterior displacement Anteroposterior alignment anterior to 15-degree angle
Borderline acceptable	Lateral alignment anterior to 10 degrees 2 to 5-mm anterior displacement Anteroposterior alignment 15-degree varus to 15-degree valgus
Unacceptable	Lateral alignment 10-30 degrees from anterior to 2 mm displacement Anteroposterior alignment 15-degree varus to 15-degree valgus Lateral alignment >30 degrees from anterior

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## Reduction



Open (vs. closed)

- Higher quality
- Low threshold
- Smith-Pete



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## Open Reduction



### Heuter/ Mini Smith-Pete

- Excellent neck exposure



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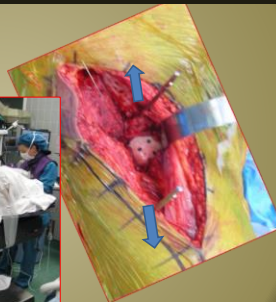
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## Open Reduction



- Traction (or not)



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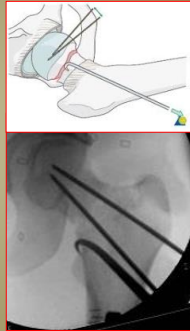
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# Open Reduction



- Joy stick(s)
  - Rotate
  - Push/pull(?)
  - Provisional fixation
- Bone hook
  - pull (rotate)




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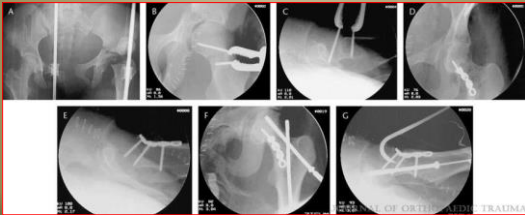
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FIGURE 4. A, A 15-year-old female involved in a high-speed motor vehicle accident. The patient sustained a left external iliac injury requiring emergent repair. The reduction was then temporarily held with a 3.5-mm pelvic reconstruction plate (D and E). Definitive fixation was placed percutaneously using small incisions (F and G). The bone hook prevents subluxation through the acetabular fracture.

### Open Reduction of Intra-articular Hip Fractures Using a Modified Smith-Petersen Surgical Exposure

Molnar, Robert B., Roett, M.L. (Chp) Jr  
Journal of Orthopaedic Trauma, 21(7):490-494, August 2007  
doi: 10.1097/BOT.0b013e31804a7771

- Clamps
- Small or mini-frag plates



Wolters Kluwer | Lippincott Williams & Wilkins

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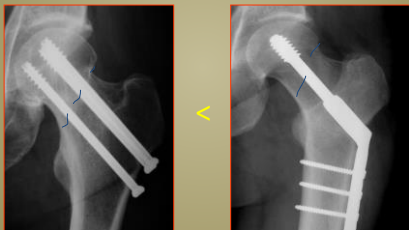
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# Fixation



- Mechanical Fixation in Vertical Neck Fx



Baitner et al, Clin Orthop, 1999

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# Fixation



- Mechanical Fixation in Vertical Neck Fx



Grossman et al., OTA, 2001

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# Fixation



- Cadaveric study, multiplanar cyclic loading



Aminian et al, JBJS, 2007

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# Fixation



Lin et al. Proximal femoral locking plate with cannulated screws for the treatment of femoral neck fractures. Orthopedics, 2012; 35(1) 1-5.

- Clinical study
- 41 patients
- Mean age 47 (21-65)



Figure: The proximal femoral locking plate (a) with a locking cannulated screw (b), locking screw (c), long thread cannulated cancellous screw (d), and short thread cannulated cancellous screw (e).

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# Fixation



Lin et al. Proximal femoral locking plate with cannulated screws for the treatment of femoral neck fractures. Orthopedics, 2012; 35(1) 1-5.

- 2 nonunions (5%), 2 AVN requiring surgery (5%)
- 63% excellent and 20% good results (Harris hip)



Figure 2. Preoperative anteroposterior (A) and lateral (B) radiographs, day of surgery anteroposterior (C) and lateral (D) radiographs, and 12-week postoperative anteroposterior (E) and lateral (F) radiographs of a 43-year-old man with a left femoral neck fracture.

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# Fixation



Lin et al. Proximal femoral locking plate with cannulated screws for the treatment of femoral neck fractures. Orthopedics, 2012; 35(1) 1-5.

	Garden Classification				All
	Type I	Type II	Type III	Type IV	
n	3	9	16	11	
Time to heal, wk	12.2	12.2	15.9	18.4	
Harris Hip Score, No. (%)					
Excellent	3 (100)	8 (89)	12 (67)	3 (27)	63%
Good	0 (0)	1 (11)	4 (25)	3 (27)	20%
Moderate	0 (0)	0 (0)	1 (6)	2 (19)	7%
Poor	0 (0)	0 (0)	1 (6)	2 (27)	10%
Complications, No.					
Nonunion	0	0	1	1	2
AVN requiring surgery	0	0	1	1	2



lateral (D) radiographs, and 12-week postoperative lateral (E) and lateral (F) radiographs of a 43-year-old man with a left femoral neck fracture.



Figure 2. Preoperative anteroposterior (A) and lateral (B) radiographs, day of surgery anteroposterior (C) and lateral (D) radiographs, and 12-week postoperative anteroposterior (E) and lateral (F) radiographs of a 43-year-old man with a left femoral neck fracture.

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# Fixation



What do the "Experts" say?

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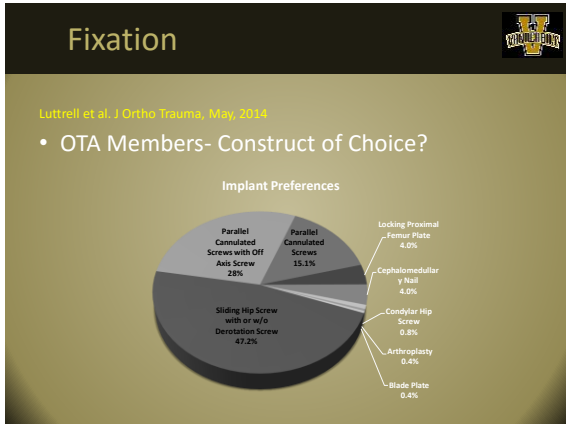
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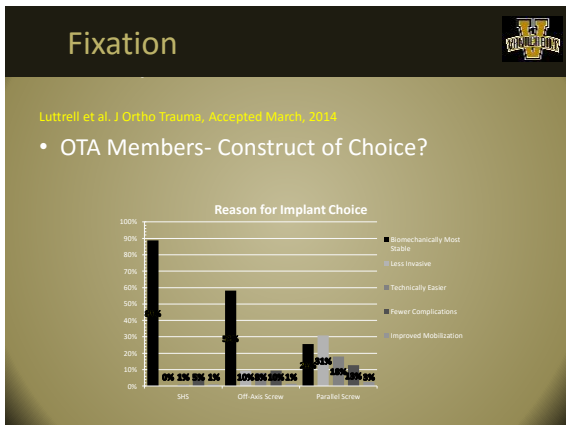
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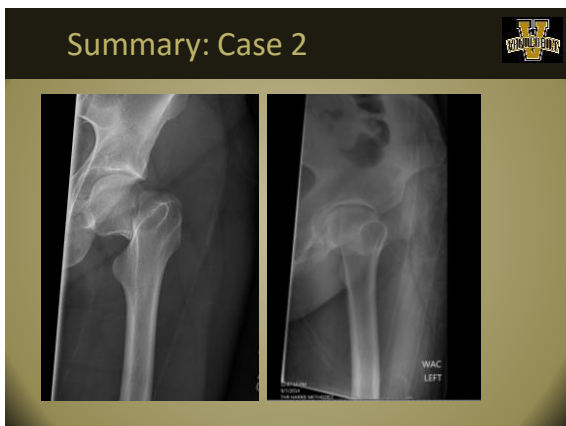
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Summary: Case 2



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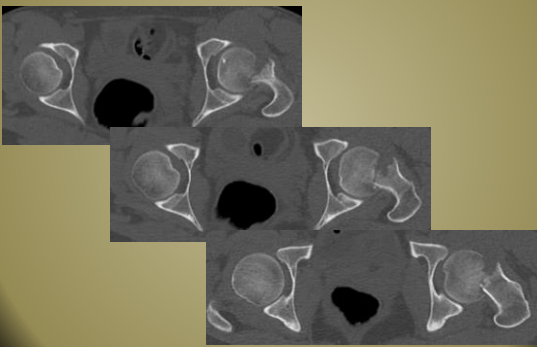
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Summary: Case 2



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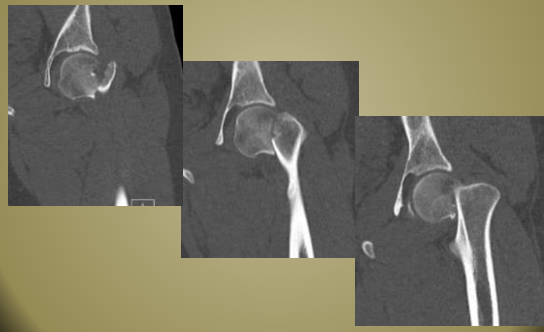
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Summary: Case 2



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Summary: Case 2



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Summary: Case 2



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Summary: Case 2



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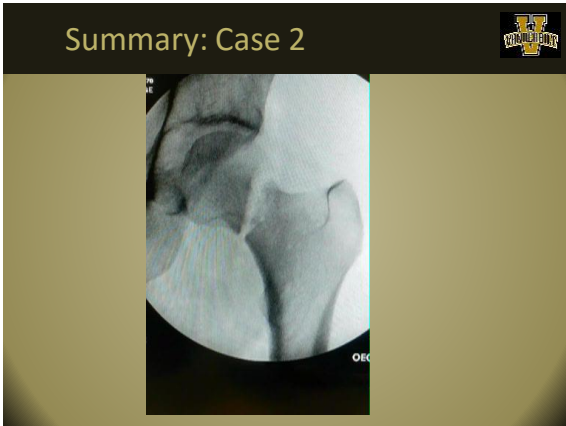
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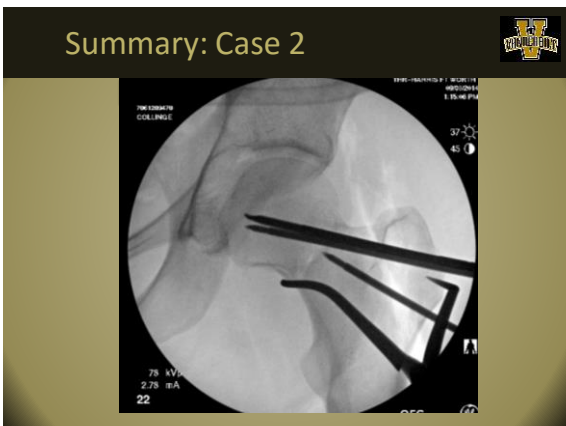
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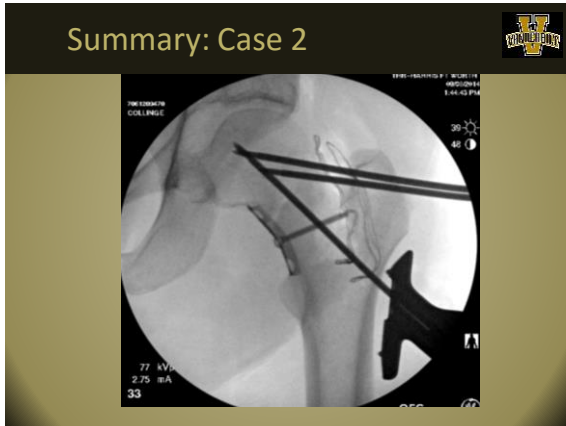
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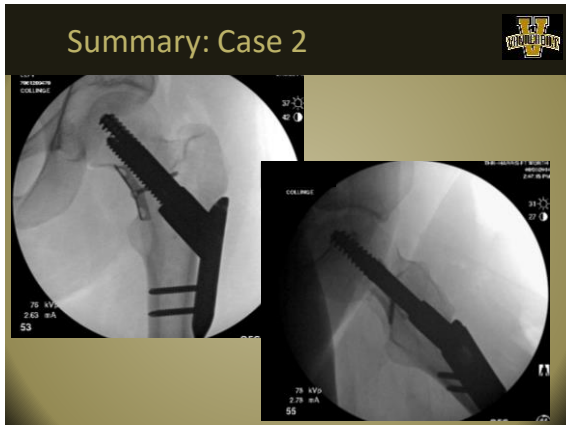
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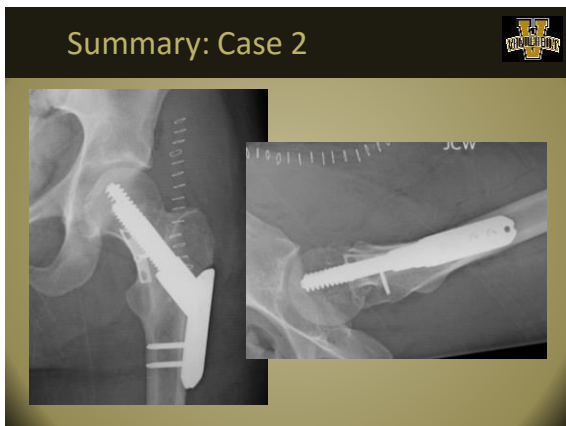
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### Summary: Case 2



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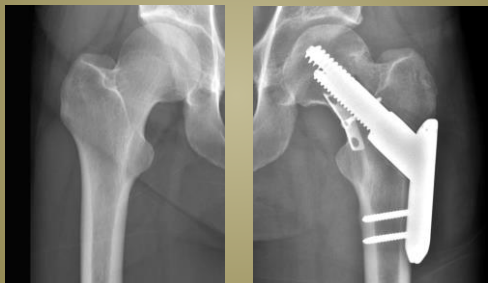
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### Summary: Case 2



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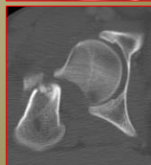
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### Conclusions



Femoral neck Fx in young adult

- Assessment
- Pre-op planning
- Reduction
- Fixation
- Complication management



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## Conclusions



Pauwels III femoral neck Fx in young adult

- We need to understand the injury better



- Requires a thoughtful solution

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Thank You

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## A Rational Approach?

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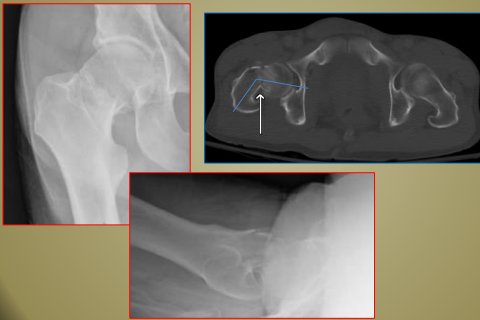
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## Pre-operative Assessment



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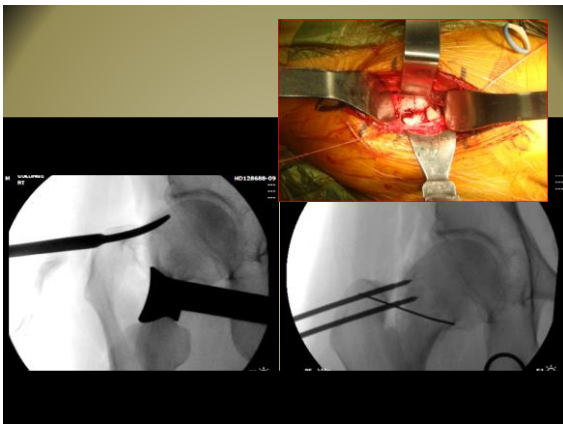
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## Fixation

- Plate-screw with anti-rotation  
– DHS + AR screw



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## Discussion



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## “Schizophrenic” Thinking

- schiz-o-phre-ni-a [skit-suh-free-nee-uh, -freen-yuh]
- *noun*
- 1. *Psychiatry.* . Also called dementia praecox. A mental disorder characterized by some, but not necessarily all of the following features: emotional blunting, intellectual deterioration, social isolation, disorganized thought and behavior, delusions, and hallucinations.
- 2. a state characterized by the coexistence of contradictory or incompatible elements.

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- Vertical Shear Fractures of the Femoral Neck A Biomechanical Study.
- Baitner, Avi C. MD; Maurer, Stephen G. MD; Hickey, Derrick G. MD; Jazrawi, Laith M. MD; Kummer, Frederick J. PhD; Jamal, Joseph BS; Goldman, Sara BS; Koval, Kenneth J. MD

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- [December 2002 Volume 33, Supplement 3, Pages 24–32](#)
- Analysis of fracture gap changes, dynamic and static stability of different osteosynthetic procedures in the femoral neck
- [F.A. Bonnaire, A.T. Weber](#)

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- Internal Fixation of Femoral Neck Fractures With Posterior Comminution: A Biomechanical Study
- Kauffman, Jeffrey I.; Simon, Jordan A.; Kummer, Frederick J.; Pearlman, Charles J.; Zuckerman, Joseph D.; Koval, Kenneth J.

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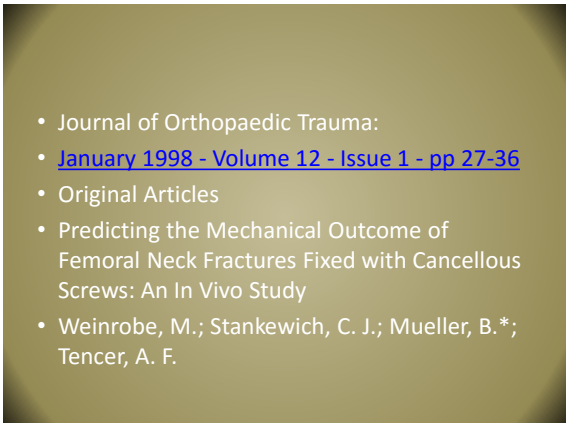
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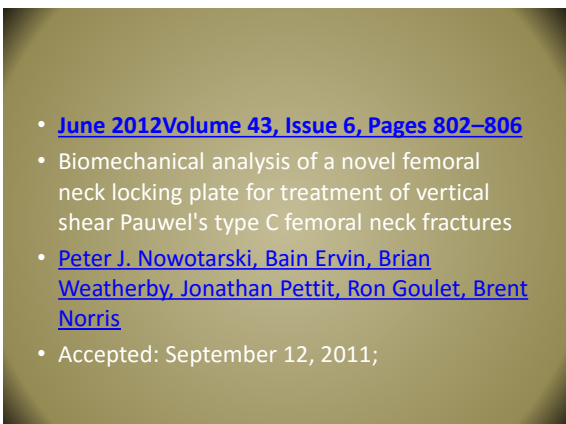
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- **Displaced Femoral Neck Fractures in Young Adults Treated With Closed Reduction and Internal Fixation**
- Hui-Kuang Huang, MD; Yu-Ping Su, MD; Chuan-Mu Chen, MD; Fang-Yao Chiu, MD; Chien-Lin Liu, MD
- **Orthopedics**
- **[December 2010 - Volume 33 - Issue 12](#)**

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- [Injury](#)
- [Volume 28, Issue 2, March 1997, Pages 135–139](#)
- <http://ars.els-cdn.com/content/image/S00201383.gif>  
[class="toprightlogo" />](#)
- Paper
- Percutaneous cannulated screw fixation of femoral neck fractures: the three point principle
- C.A. Bout, D.M. Cannegieter, J.W. Juttman

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- Journal of Orthopaedic Trauma:
- [February 2000 - Volume 14 - Issue 2 - p 131](#)
- Abstracts From The 15Th Annual Meeting Of The Orthopaedic Trauma Association
- †A biomechanical analysis of fixation constructs in high angle femoral neck fractures
- Sirkin, Michael; Grossman, Mark G.; Renard, Regis L.; Sabatino, Christopher T.; Doumas, Christopher; Reilly, Mark C.; Behrens, Fred F.

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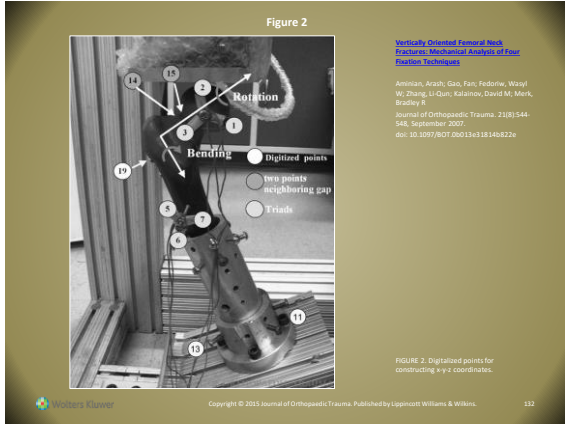
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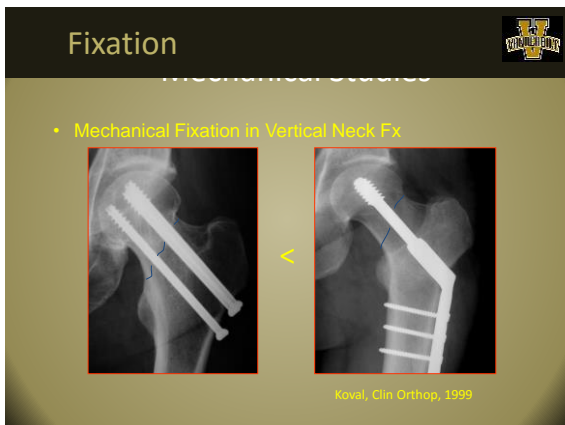
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### Fixation

- Mechanical Fixation in Vertical Neck Fx

Grossman et al., OTA, 2001

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### Fixation

- Cadaveric study, multiplanar cyclic loading

Merk, JBJS, 2007

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### Disclosure

- I have failed.

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