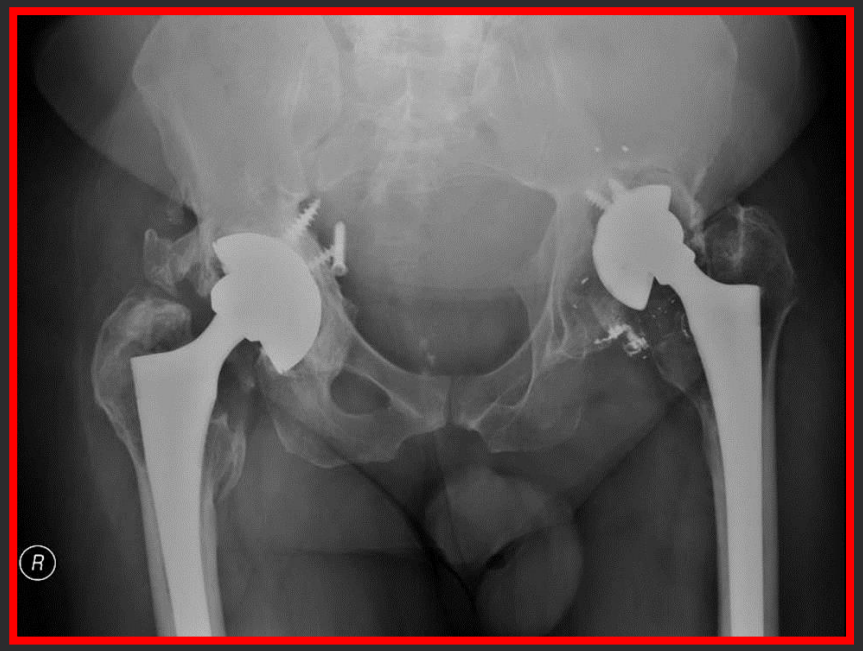
Evaluating and Treating Acetabular Bone Loss with Pelvic Discontinuity



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Disclosures

- **Consultant**
  - Zimmer
    - PERSONA TKA evaluation team
    - Zimmer Education
  - Smith and Nephew
  - Medacta
  - Biorad Medisys
  - Cardinal Health
- **Royalties**
  - Elsevier Publishing
- **Financial Consulting**
  - March Altus
  - Healthpoint Capital
  - GLG Healthcare

Reasons for Acetabular Revision

Most common etiologies:

- Instability
- Peri-prosthetic Infection
- Polyethylene wear / osteolysis
- Component malposition
- Aseptic loosening
- Peri-prosthetic Fracture

Bozick KJ, JBJS-A 2009

Goals of Acetabular Reconstruction

1. Utilization of cementless component (USA)

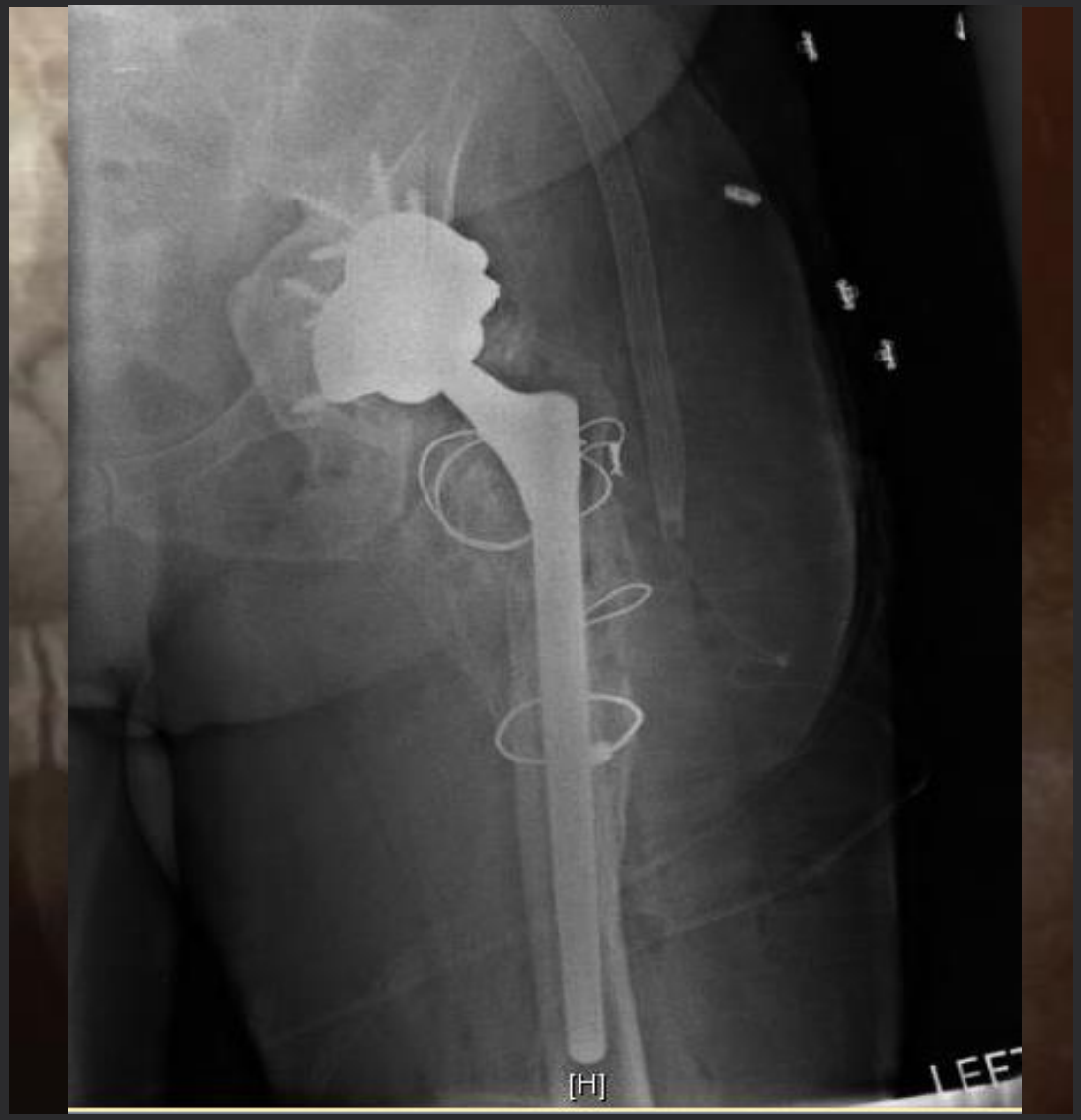
2. Intimate contact with host bone

3. Stable mechanical construct
   Minimize micro-motion
   Allow for biologic fixation

4. Physiologic stress distribution
   Surrounding acetabular bone stock

Sporer SM, JBJS-A 2011

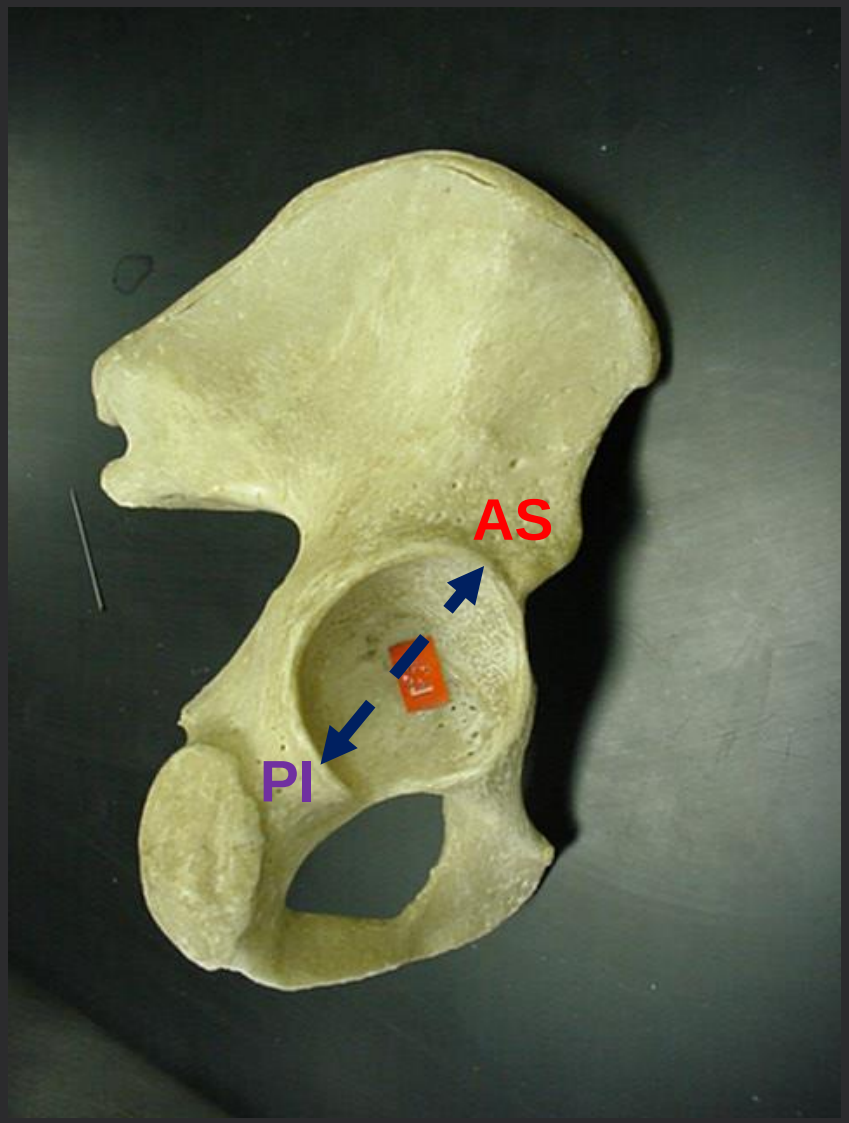
What is the Major Challenge?



Acetabular Defects in Revision THA

****COLUMN SUPPORT****

1. Anterosuperior (AS)
2. Posteroinferior (PI)



Gross Classification

TABLE I Scale for Assessment of Bone Loss in the Acetabulum

Type I	*No notable loss of bone stock.* Amount of bone loss is less than that which would require a revision component. There has been no migration of the primary component into the ilium, and both columns are largely intact.
Type II	*Contained loss of bone stock.* There is cavitary or volumetric enlargement of the acetabulum. If the cup does extend beyond the ilioischial line (protrusio), the defect can still be considered type II provided that the columns are intact.
Type III	*Uncontained (segmental) loss of bone stock involving <50% of the acetabulum, primarily affecting either the anterior or the posterior column.* Bone loss is considered uncontained if it is not amenable to treatment with morselized bone graft. The sum of all segments of bone loss in either the anterior or the posterior column allows ≥50% cup coverage by host bone (as assessed preoperatively with templates).
Type IV	*Uncontained (segmental) loss of bone stock >50% of the acetabulum affecting both the anterior and the posterior column.* Type IV is identical to type III except that the sum of the segmental bone loss in the columns exceeds 50%. There is no pelvic discontinuity.
Type V	*Acetabular defect with contained loss of bone stock in association with pelvic discontinuity.* Any pelvic discontinuity is considered a type-V defect regardless of the amount of bone loss.

Gross AE et al. JBJS-Am 2001

AAOS Classification

Table 1

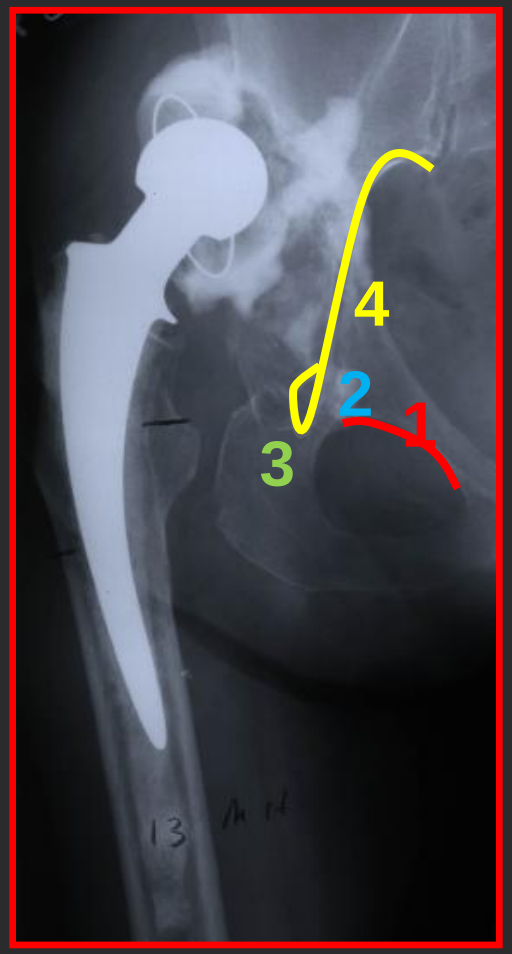
American Academy of Orthopaedic Surgeons Classification of Acetabular Deficiencies[10]

Type	Description
I	Segmental defect
II	Cavitary defect
III	Combined segmental and cavitary defect
IV	Pelvic discontinuity
A	Discontinuity with mild segmental or cavitary loss
B	Discontinuity with moderate to severe segmental or cavitary loss
C	Discontinuity with prior pelvic irradiation
V	Hip arthrodesis

Sheth NP et al. JAAOS 2013

Assessing Acetabular Bone Loss: Paprosky Classification

1. **Superior migration of hip center**
   - Reference: superior obturator line
   - Superior acetabular dome loss
2. **Osteolysis of teardrop**
   - Inferomedial and medial wall bone loss
3. **Ischial osteolysis**
   - Posteroinferior column loss
4. **Kohler's Line – ilioischial line**
   - Anterosuperior column and Medial wall loss



Paprosky WG JOA 1994

Classifying Defects

Table 2

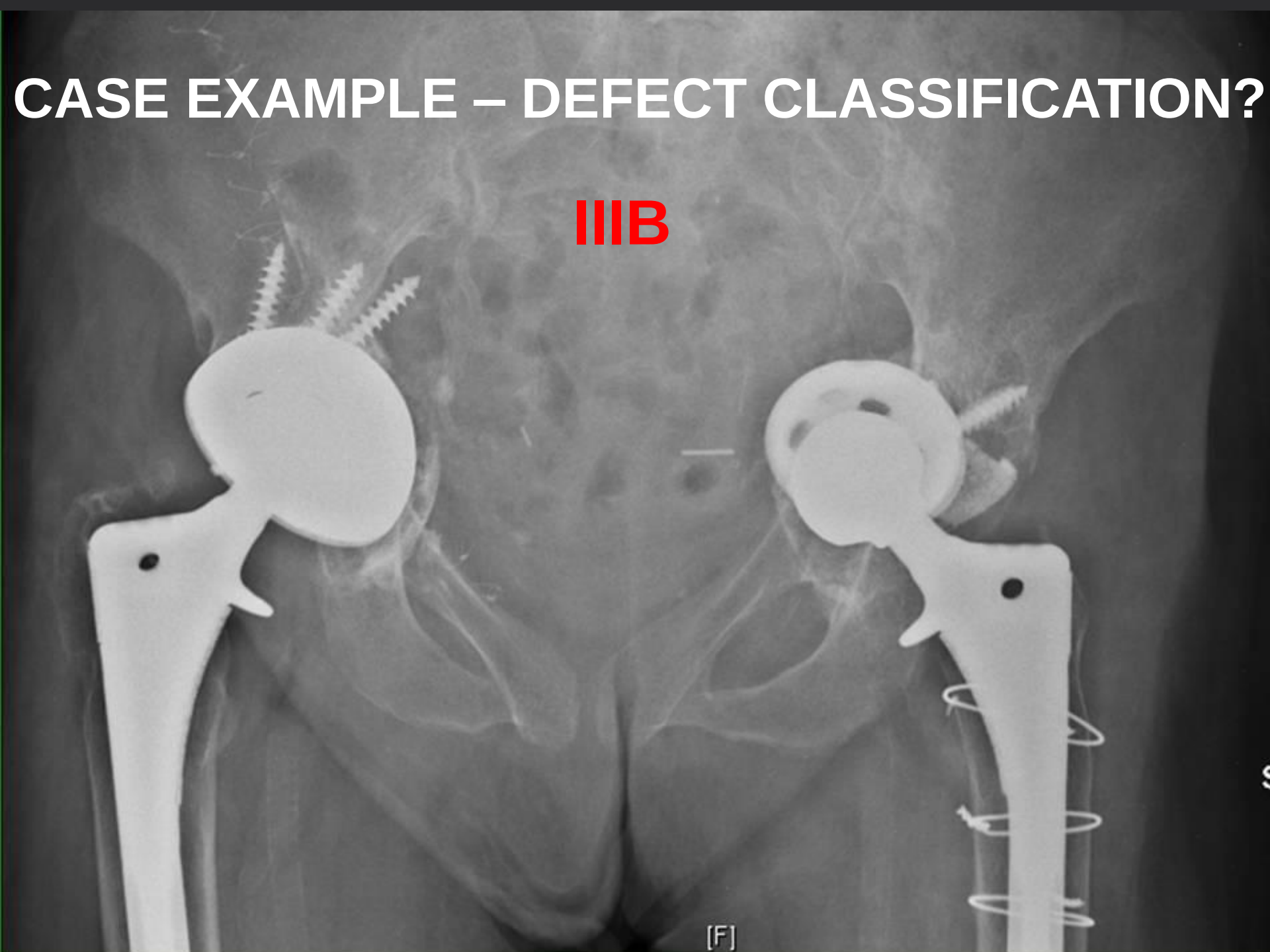
Paprosky Classification of Acetabular Bone Loss[11]

Type	Femoral Head Center Migration	Ischial Osteolysis	Kohler Line	Teardrop
I	None	None	Intact	Intact
IIA	Mild (<3 cm)	None	Intact	Intact
IIB	Moderate (<3 cm)	Mild	Intact	Intact
IIC	Mild (<3 cm)	Mild	Disrupted	Moderate lysis
IIIA	Severe (>3 cm)	Moderate	Intact	Moderate lysis
IIIB	Severe (>3 cm)	Severe	Disrupted	Severe lysis

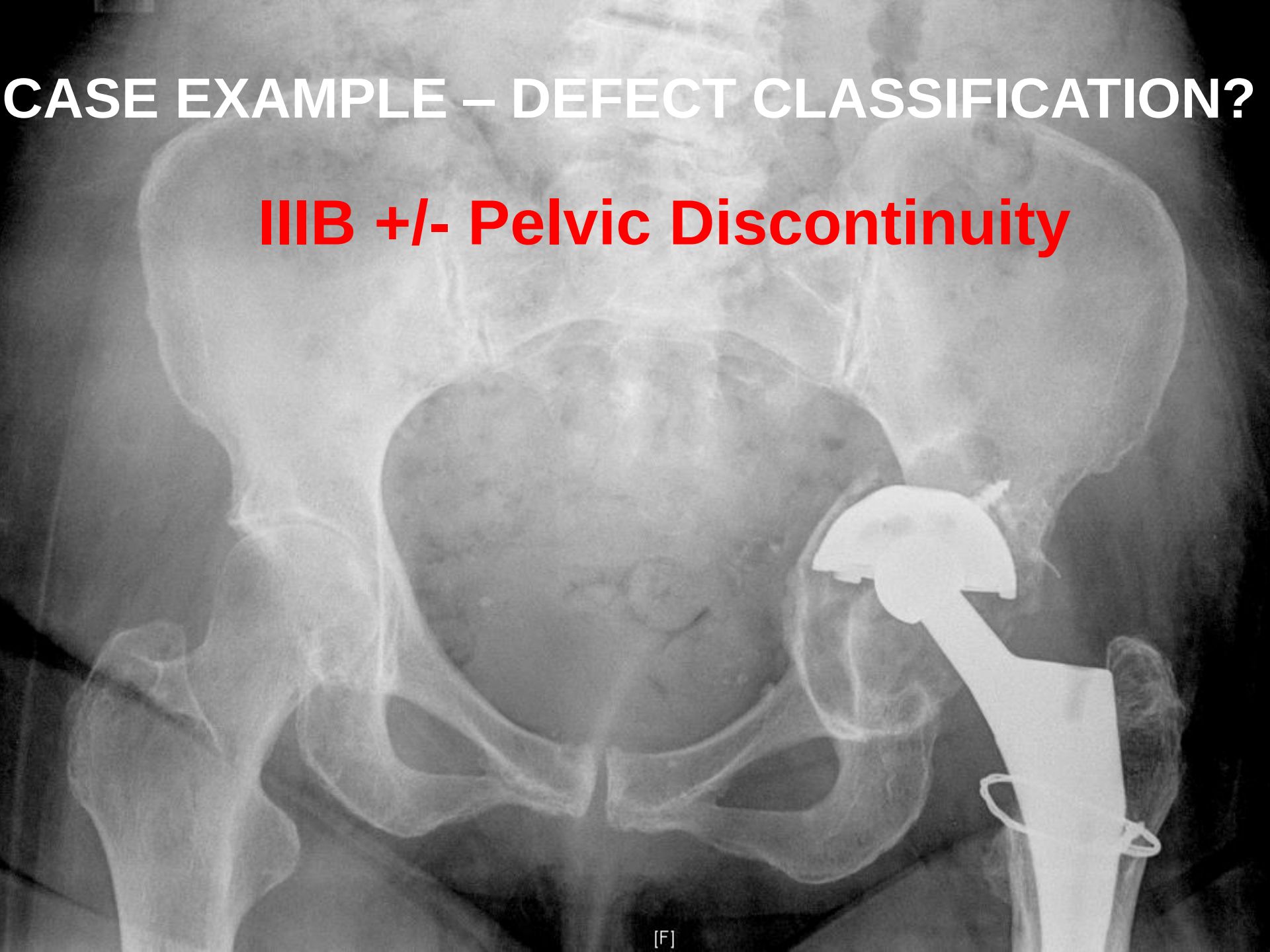
Sheth NP et al. JAAOS 2013

CASE EXAMPLE – DEFECT CLASSIFICATION?

IIIB



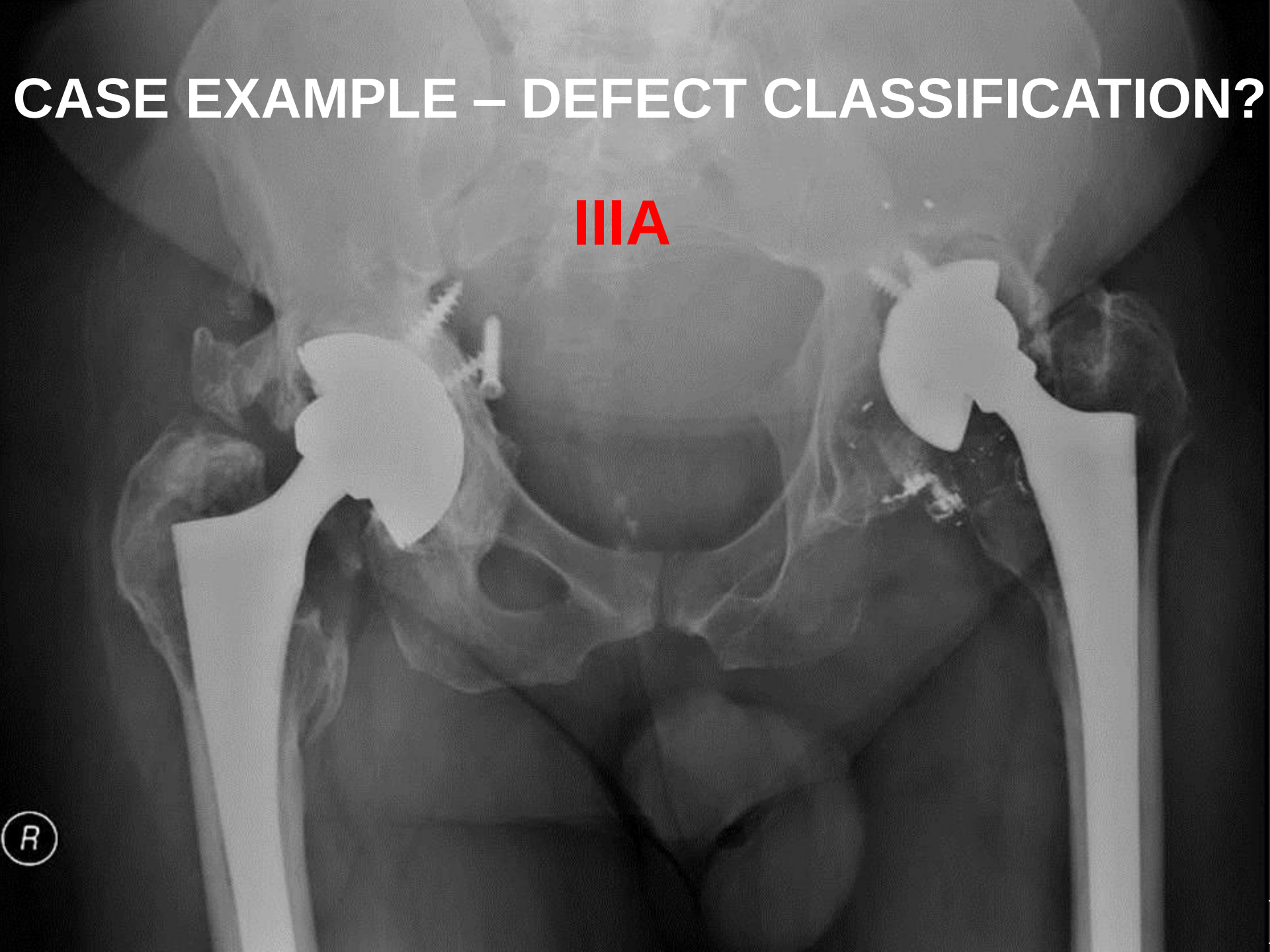
CASE EXAMPLE – DEFECT CLASSIFICATION?



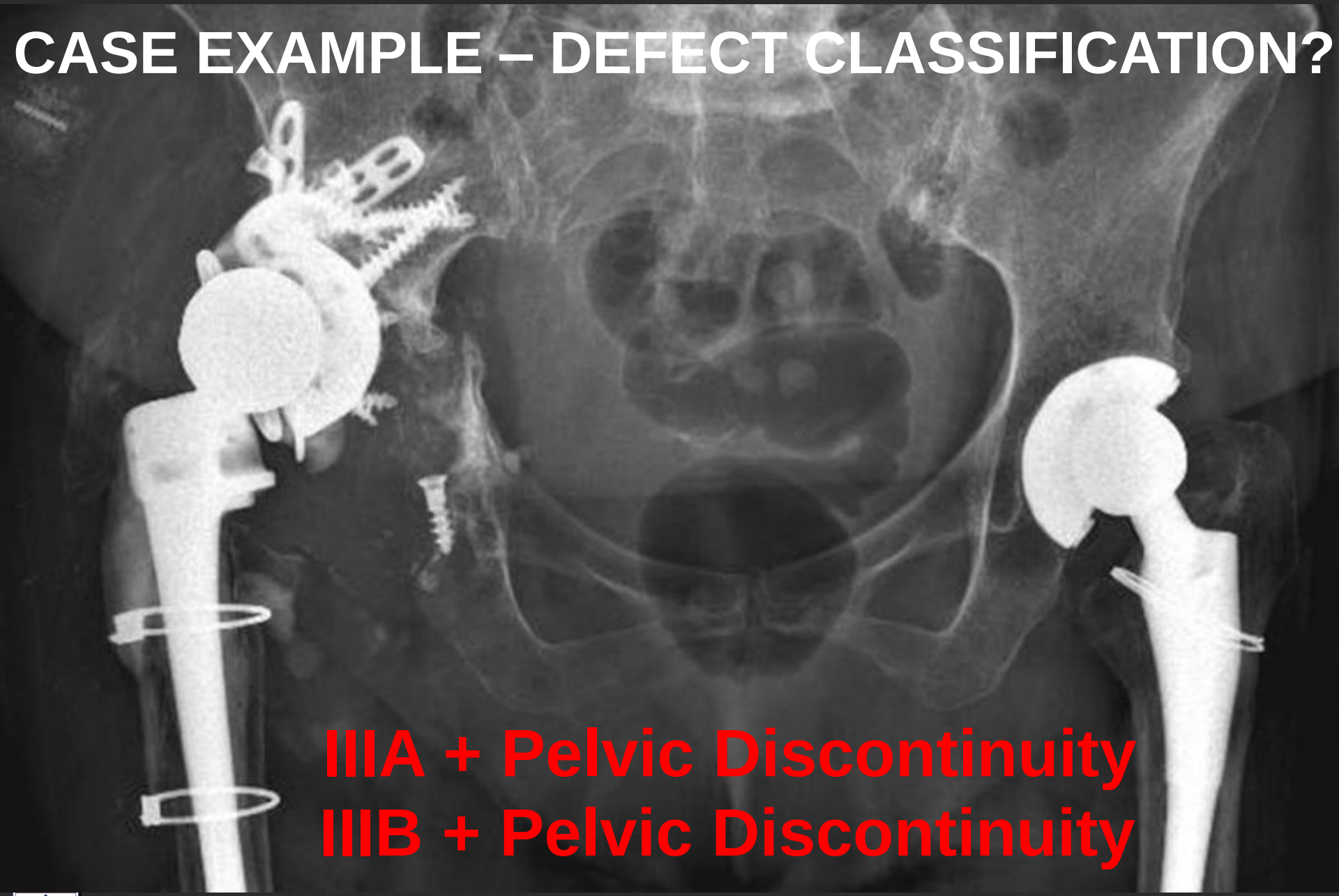
IIIB +/- Pelvic Discontinuity

[F]

CASE EXAMPLE – DEFECT CLASSIFICATION?



CASE EXAMPLE – DEFECT CLASSIFICATION?



IIIA + Pelvic Discontinuity
IIIB + Pelvic Discontinuity

Paprosky Acetabular Bone Loss Classification

Type I – Undistorted hemispherical acetabulum

Type II – Distorted acetabulum but intact columns

Type III – Distorted and Non-supportive columns

IIIA – UP + OUT

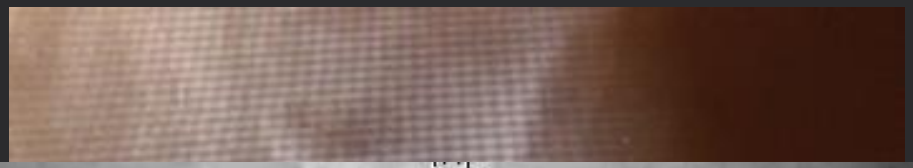
IIIB – UP + IN

Paprosky WG JOA 1994

Radiographic Assessment

Type IIIA – UP and OUT [30-60% bone loss]

- **Bone loss is superior and lateral**
  1. Superior migration > 3 cm
  2. Moderate teardrop lysis
  3. Moderate ischial lysis
  4. Kohler's line intact
- Rx: Jumbo cup (hemispherical, cementless cup)
  - +/- structural graft **OR** +/- Augment + adjuvant screws



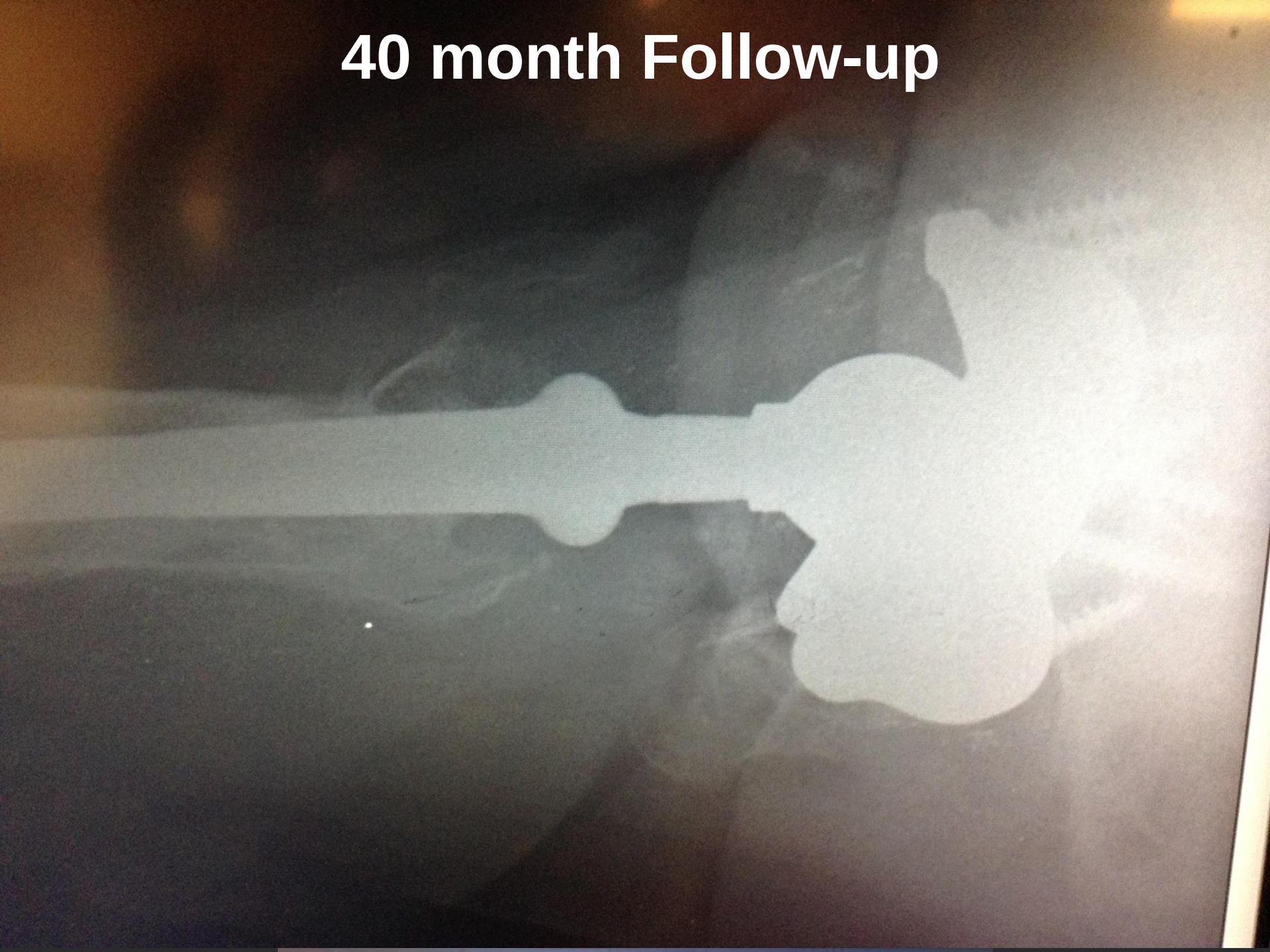
22 month Follow-up

Radiographic Assessment

Type IIIB – UP and In [> 60% bone loss]

- **Bone loss is superior and medial**
  1. Superior migration > 3 cm
  2. Severe teardrop lysis
  3. Severe ischial lysis
  4. Kohler's line **VIOLATED**
  5. **+/- PELVIC DISCONTINUITY**
- Rx: Jumbo cup (hemispherical, cementless cup)
  - Augment or cup/cage , structural allograft **OR** CTAC

40 month Follow-up



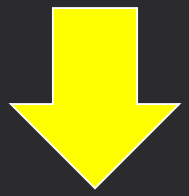
How common is this Problem?

Incidence of Pelvic Discontinuity < 1 %

Berry DJ JBJS-Am 1999

Why is it an Unsolved Problem?

Chronic Pelvic Discontinuity
Healing Potential



Atrophic Non-union

Options for Pelvic Discontinuity

- **Acute / Potential for healing**
  - ORIF / Plating of the discontinuity
- **Chronic Discontinuity**
  - Cages / Ring Construct
  - Cage + Augments
  - Acetabular Allograft
  - Cup-cage Construct
  - Custom Triflange Component
  - Jumbo Cup +/- Augments
  - Acetabular Distraction +/- Augments

How to Define Pelvic Discontinuity

1. Define discontinuity with COBB elevator
2. Assess chronicity of the discontinuity
3. Superficially debride the discontinuity
   - AVOID DESTABLIZATION OF DISCONTINUITY
4. Bone graft the discontinuity

Acetabular Defects with Ring/Cage Reconstruction

Loosening After Acetabular Revision: Comparison of Trabecular Metal and Reinforcement Rings. A Systematic Review

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Acetabular Defects with Ring/Cage Reconstruction

Table 2
Revision Rings – All Defects.

Author	Year	Implant	# Hips	Mean Age	Mean FU Years	Aseptic Clin/ Radiol. Loose	Reason for Revision	
							Septic Loosening	Aseptic Loosening
Berry [37]	1992	Schneider-Burch	42	62	5	12	12	5
Rosson [38]	1992	Schneider-Burch	20	62	5	5	0	0
Zehnter [39]	1994	Schneider-Burch	27	52	2.8	0	0	0
Levai [40]	1996	Schneider-Burch	2	66.1	3.1	0	0	0
Garbuz [41]	1996	Schneider-Burch	8	60	7.5		1	0
Starker [42]	1998	Schneider-Burch	41	x	5.8	2	0	2
Schatzker [43]	1999	Schneider-Burch	38	66.8	6.6	2	0	2
Boehm [44]	1999	Schneider-Burch	26	61	4.5	1	0	1
van der Linde [45]	2001	Schneider-Burch	16	67.5	11.7	3	1	0
Winter [46]	2001	Schneider-Burch	38	66	7.3	2	0	2
Goodman [47]	2004	Schneider-Burch	42	66	4.9	1	2	5
Ilchmann [48]	2006	Schneider-Burch	40	70	4.7	16	x	2
Ochs [49]	2008	Schneider-Burch	79	57	2.9	14	x	0
Gaiani [50]	2009	Schneider-Burch	60	82	6	0	0	0
Starker [42]	1998	Ganz	76	x	5.4	2	0	1 (1.3%)
Siebenrock [51]	2001	Ganz	36	62.5	11.4	3	1	2
Eggli [52]	2002	Ganz	5	61.7	8	2	0	2
Gerber [53]	2003	Ganz	50	69	9.0	3	1	3
Capone [54]	2004	Ganz	25	72.5	4.6	3	0	0
Uchiyama [55]	2010	Ganz	43	60.8	8.0	5	x	0
Korovesis [56]	1992	Mueller	30	61	2.5	0	0	0
Rosson [38]	1992	Mueller	46	63	5.0	16	0	5
Gurtner [57]	1993	Mueller	150	64	7.0	15	10	9
Pascarel [58]	1993	Mueller	141	63	8.0	9	2	0
Dihlmann [59]	1994	Mueller	42	71	2.5	0	0	0
Levai [40]	1996	Mueller	28	66.1	3.1	2	0	1
Stockl [60]	1997	Mueller	47	68	6.4	2	2	2
Panski [61]	1997	Mueller	14	61.3	6.6	2	2	0
Starker [42]	1998	Mueller	41	x	6.6	2	2	0
Schatzker [43]	1999	Mueller	57	62.9	8.3	8	1	8
Boehm [44]	1999	Mueller	39	61	4.5	1	0	1
van der Linde [45]	2001	Mueller	26	68	9.1	3	2	1
Eggli [52]	2002	Mueller	2	61.7	8	0	0	0
Schlegel [62]	2006	Mueller	164	69	6.0	2	7	6
Total		Schneider-Burch	479	65.3	5.1	59 (12.3%)		19 (4%)
Total		Ganz	235	65.7	7.5	18 (7.7%)		8 (3.4%)
Total		Mueller	827	65.2	5.5	62 (7.5%)		33 (4%)
TOTAL		ALL	1541	65.3	5.7	139 (9.0%)	46 (3.0%)	60 (3.9%)

Acetabular Defects + Pelvic Discontinuity with Cage Reconstruction

Author	Journal	# of Hips	Mean F/U	Outcomes	Conclusion
Paprosky	*CORR 2006*	*16*	*5 years*	*4/16 required Re-revision for Aseptic Loosening*	*25% Failure*
Albolghasemian	*JBJS-Am 2014*	*19*	*7 years*	*49.9% Survivorship*	*50% Failure*
Vigdorchik	*Hip Int 2017*	*24*	*3.5 years*	*14/24 Broken cage 6/10 Intact Screw Pull-out*	*67% Failure*

High failure Rate of cages alone in the setting of PD

Acetabular Defects in Discontinuity Cage + Augments

Author	Journal	# of Hips	Mean F/U	Outcomes	Conclusion
Mäkinen	*JBJS Br 2017*	*22*	***3.3 years***	***3 Failures in 2 Pts. (Previous Tumor Res)***	***86% Survival***

Acetabular Allograft

Author	Journal	# of Patients	Mean F/U	Outcome	Conclusion
Abolghasemian	*JBJS-Am 2014*	*50*	*5.8 years*	*Aseptic loosening Higher with +PD*	***56% Survival 10 Years***
Regis D	*J of A 2012*	*18*	*13.5 years*	*3/18 Re-revision 2 Grafts resorbed 13/18 cages stable*	***72% Survival***
Regis D	*J of A 2008*	*56*	*11.7 years*	*49/56 incorporated 5/56 aseptic loosening*	***88% Survival***

- **Concern for:**
  - **Infection**
  - **Graft resorption**
  - **Cage failure/fracture**

Acetabular Defects [+/- Discontinuity] with Cup-Cage Reconstruction

Author	Journal	# of Hips	Mean F/U	Outcomes	Conclusion
Kosashvili	*JBJS-Br 2009*	*24*	***2.2 years***	*0 failures for aseptic Loosening*	*100%*
Ballester	*Hip Int 2010*	*19*	***2 years***	*1/20 required Re-revision for Aseptic Loosening*	*95%*
Abolghasemian	*Sem Arth 2012*	*26*	***3.9 years***	*2/20 required Re-revision for Aseptic Loosening*	*90%*
Amenabar	*CORR 2015*	*67*	***6.2 years***	*5 yr Survival – 93% 10 yr Survival – 85%*	*85%– 93%*
Konan	*Hip Int 2017*	*24*	***6 years***	*1 excision arthroplasty 3 Dislocations No Cup-cages revised*	*100%*

CUP IS TYPICALLY PLACED TOO VERTICAL + TOO RETROVERTED

Acetabular Defects + Discontinuity with Triflange Reconstruction

Author	Journal	# of Hips	Mean F/U	Outcomes	Conclusion
Christie	CORR 2001	78	4.4 years	12 Dislocations (16%) No aseptic loosening	100%
Joshi	J of A 2002	27	4.8 years	1 Dislocations (4%) 1 Removal of CTAC	96%
Dennis	J of A 2003	24	4 years	3 CTACs loosened	88%
Holt	CORR 2004	26	4.5 years	2 Dislocations (8%) 3 CTACs Loosened (12%)	88%
DeBoer	JBJS-Am 2007	18	10 years	0% aseptic loosening 18/20 healed	90%
Taunton	CORR 2012	57	6.3 years	12 Dislocations (21%) 3 CTACs Removed 1 CTAC Loose	93%
Wind	Orthop 2013	19	2.6 years	5 Dislocations (26%) 2 CTACs Removed 1 CTAC Loose	84%
Friedrich	Int. Orth. 2014	18	2.5 Years	3 Dislocations (17%) 2 CTACs Loose	89%
Berasi	CORR 2015	24	4.75 years	No Revision for any Reason and Healed discontinuity	100%

Acetabular Defects + Discontinuity with Triflange Reconstruction

- High Cost
- Lag time for implant manufacturing ~ 6weeks
- Complex pre-op planning
  - Bone loss pattern different after implant removal
- Dislocation as High as 21%

Acetabular Defects [+/- Discontinuity] with Augments

Author	Journal	# of Hips	Mean F/U	Outcome	Conclusion
Nehme	CORR 2004	16	2.5 years	16/16 were Radiographically Stable	100%
Sporer	JOA 2006	13	3.1 years	12/13 were Radiographically Stable	92%
Sporer	JOA 2006	28	3.1 years	1/13 required Re-revision For instability	92%
Weeden	JOA 2007	33	3.8 years	1/33 failed for septic Loosening	97%
Van Kleunen	JOA 2009	97	3.8 years	9/97 revised for Sepsis or instability No aseptic loosening	91%
Siegmeth	CORR 2009	34	2 years	32/34 were Radiographically Stable	94%
Molicnik	Eur J 2014	25	1.7 years	25//25 were Radiographically Stable	100%
Batuyong	J of A 2014	24	3.1 years	22//24 were oseointegrated	92%

REVIEW

Options for managing severe acetabular bone loss in revision hip arthroplasty. A systematic review

Sameer Jain [1], *Richard J. Grogan* [1], *Peter V. Giannoudis* [2]

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[2] Academic Department of Orthopaedic Surgery, Leeds General Infirmary, Leeds, Yorkshire - UK

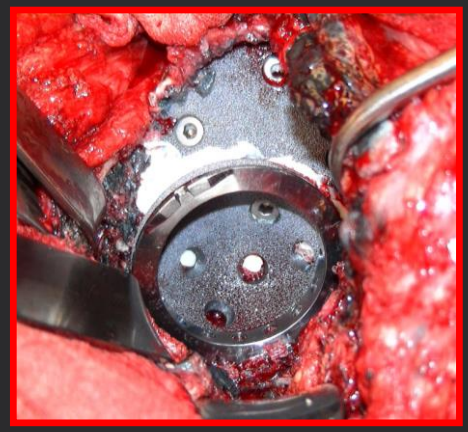
Conclusion

Revision hip arthroplasty in the presence of severe acetabular bone loss is challenging and requires a solid understanding of current techniques. A literature search of multiple databases applying specific criteria revealed a total of 50 articles of level IV scientific evidence comprising 2415 patients (2480 hips) managed with reinforcement devices (roof-reinforcement rings and anti-protrusio cages), custom-made triflanged acetabular components (CTACs), jumbo cups and tantalum metal (TM) systems. Overall, patients had improved postoperative hip scores for each technique. The use of reinforcement devices resulted in a mean revision rate of 8.2% and a mean complication rate of 29.21%. CTACs were associated with a revision rate of 15.9% and had a complication rate of 24.5%. Jumbo cups were revised in 8.8% of patients and had a complication rate of 18.4%. TM systems had an overall revision rate of 8.5% with complications seen in 18.5% of patients. CTACs had considerably higher revision rates compared to the other techniques. Jumbo cups and TM systems had lower complication rates compared to the use of reinforcement devices and CTACs. The most frequently occurring complications seen throughout the series were aseptic loosening, dislocation and infection.

Keywords: *Revision, Arthroplasty, Severe bone loss, Jumbo cup, Tantalum, Triflanged*

Trabecular Metal Augments

- **What is the function of your augment?**
  1. Primary Stability of Construct (Implant **First**)
  2. Supplemental Fixation (Implant **Second**)

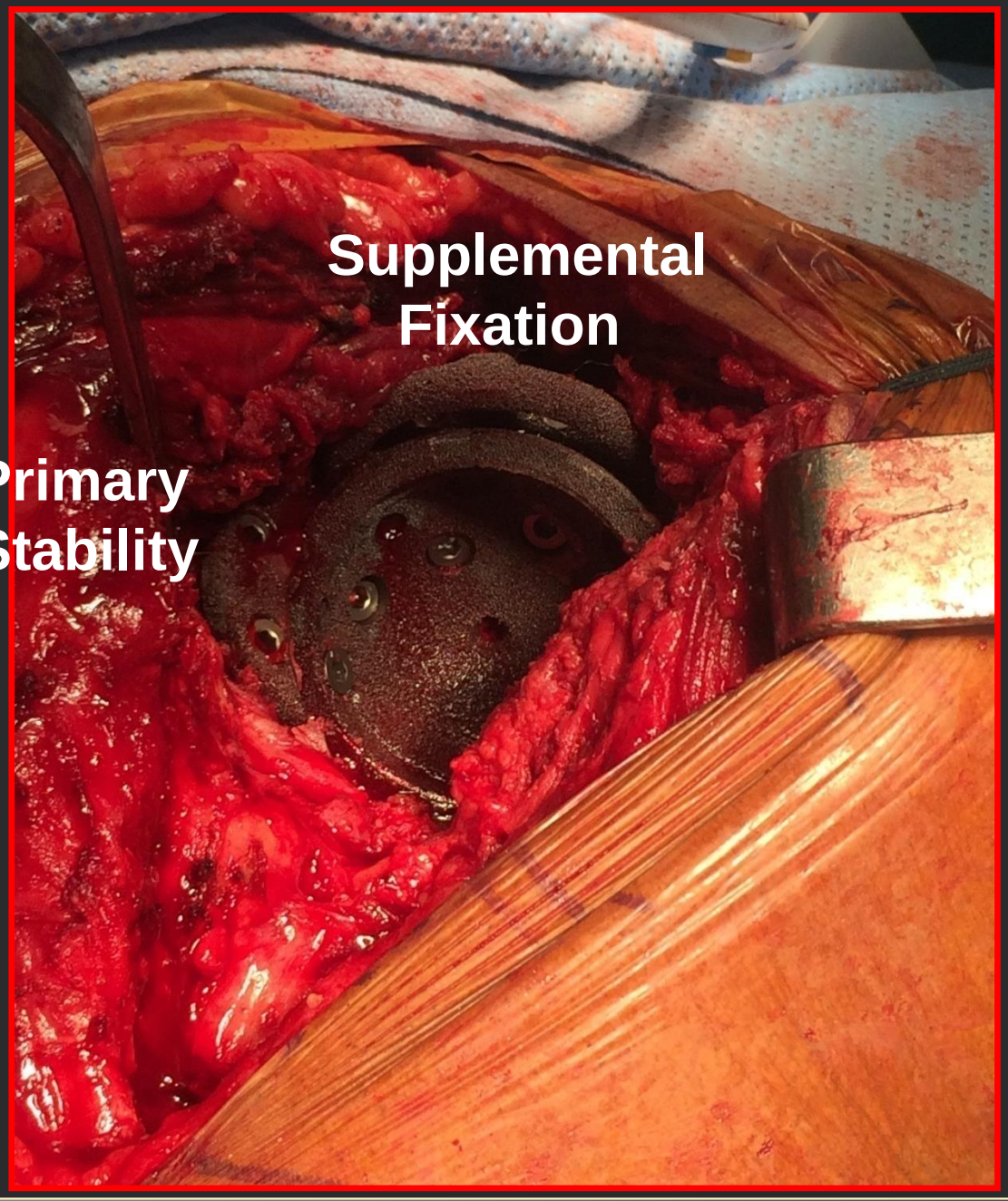


Augments should NOT be used just for volumetric bone loss!

Trabecular Metal Augments

- **Anterosuperior column loss [intracavitary]**
  - Augment for primary construct stability
- **Posterosuperior bone loss [extracavitary]**
  - Augment is for supplemental fixation
- **Posteroinferior column loss [intracavitary]**
  - Augment for primary construct stability

****ALWAYS** unitize augment to cup with **CEMENT**


Supplemental
Fixation
Primary
Stability
Anterior
Posterior

Technical Principles of Reconstruction

- **Cup needs to get a wedge fit between:**
  1. **Anterosuperior (AS) Column**
  2. **Posteroinferior (PS) Column**
- **Ream acetabulum on REVERSE**
- **At least 3-4 screws through into host bone**
  - **IF NOT ENOUGH SCREWS:**
  - Augment is used for supplemental fixation
- **At least 1 screw in Ischium or Superior Pubic Ramus**
  - **"Kickstand" screw**

Rationale for Distraction Technique

Biologic Fixation

Intra-op Customization

Compression Along Discontinuity

Healing of Discontinuity

Acetabular Distraction Technique

1. Require **AS** and **PI** column fit
   - Trabecular Metal Augments for column defects
2. Distract superior/inferior hemipelvis
3. Distractor placed in an extra-acetabular position
   1. Ream with a distractor in place
4. Multiple screws for fixation
   - Inferior "kickstand" screw

Sheth NP, Melnic CM and W.G. Paprosky, JBJS-Br, 2014
Brown NM, Shah RP and W.G. Paprosky, JBJS-Br, 2014
Sporer, SM and WG Paprosky, J Arthroplasty, 2006

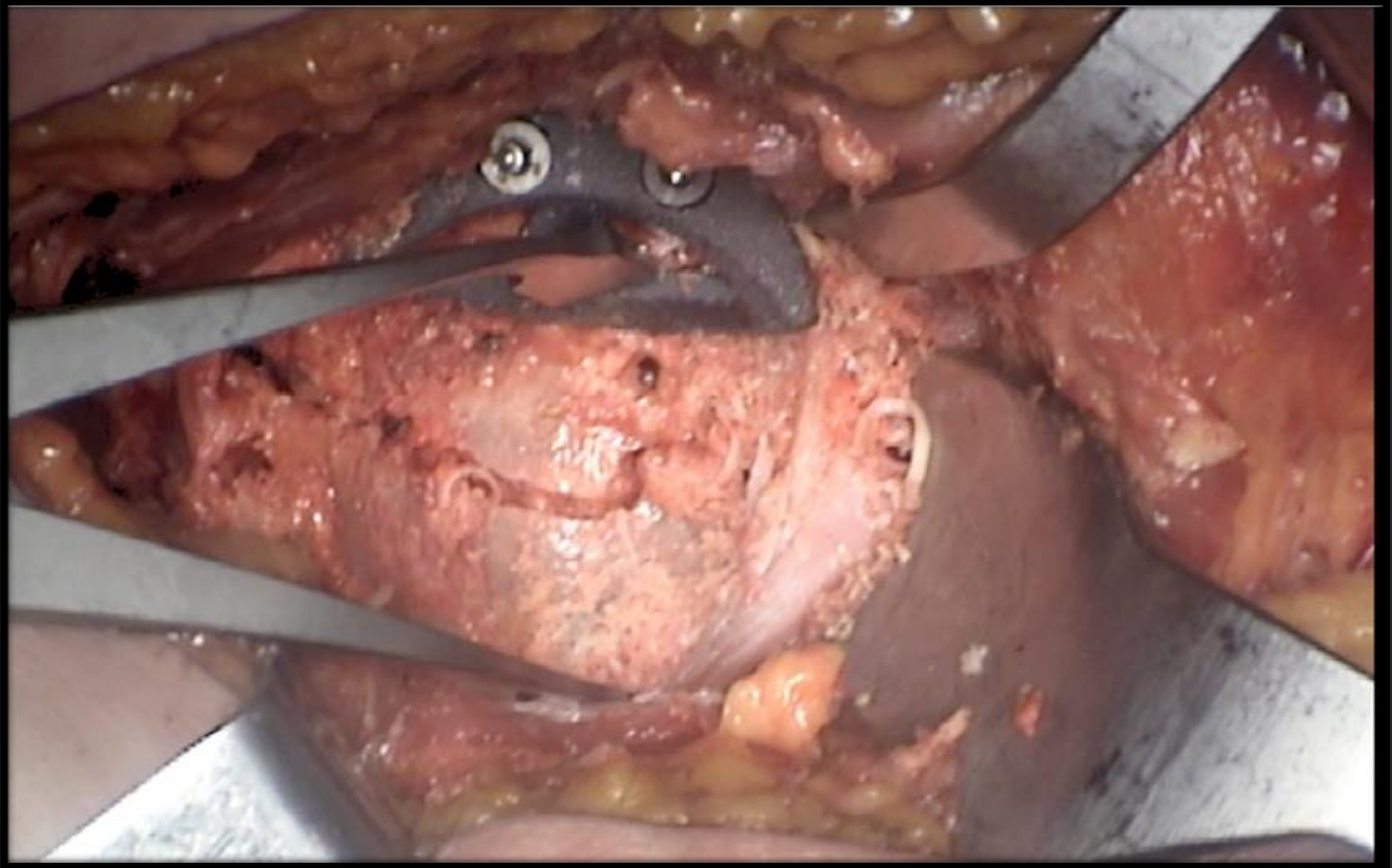
ACETABULAR DISTRACTION

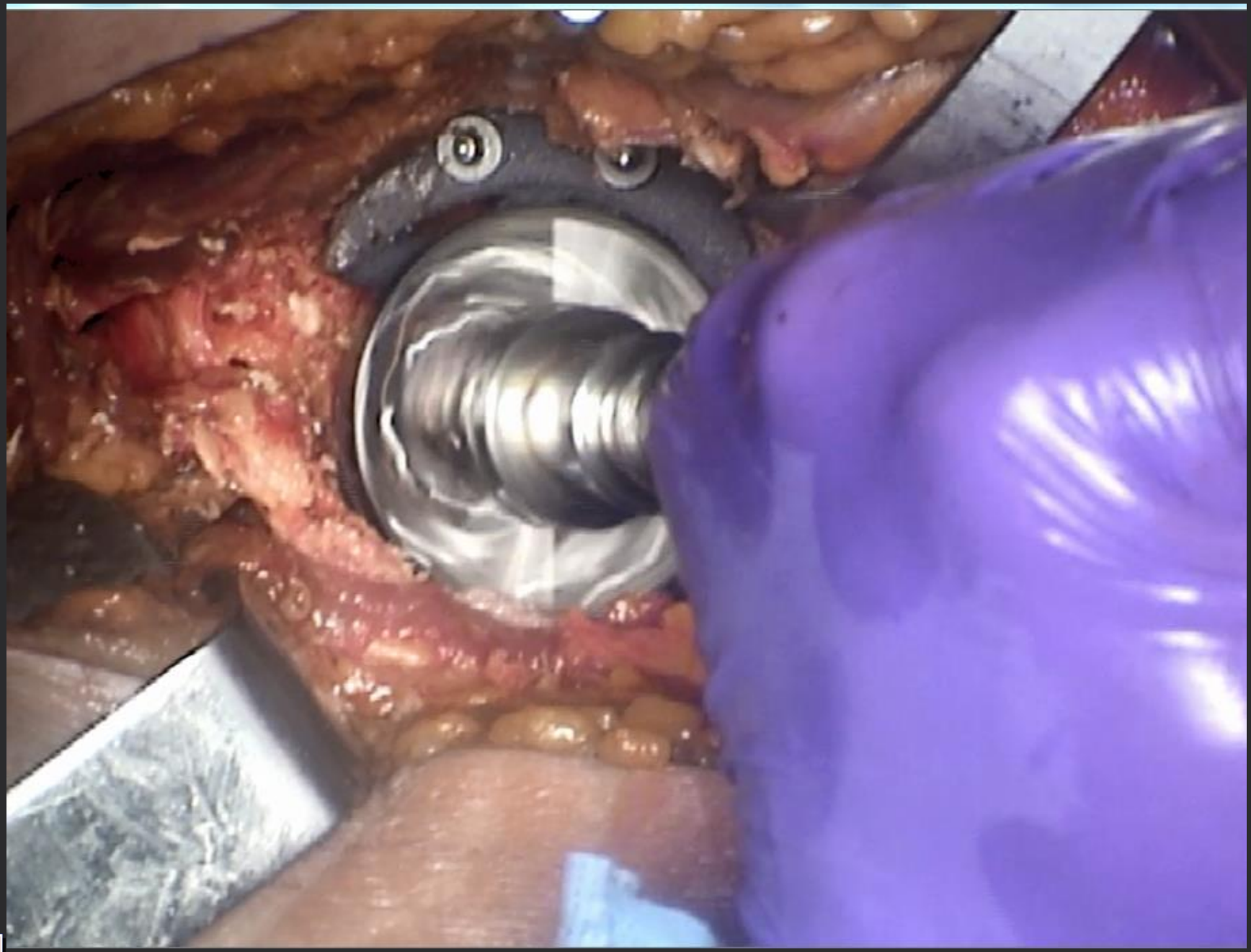
Lateral/Peripheral Distraction

+

Medial/Central Compression

Image Courtesy of WGP





Case #1 – SR s/p LTHA 22 yrs. ago

16 Month Post-operative X-rays

- 54 x 15 AS Augment - 1° stability
- 50 x 10 PS Augment – Supp. Fix.
- Size 60 Revision TM Shell

Case #2 – RK s/p LTHA 21 yrs. ago

37 Month Post-operative X-rays

Acetabular Distraction Technique

Author	Journal	# of Hips	Mean F/U	Outcomes	Conclusion
Sporer	***CORR 2012***	*20*	***2 years***	***1/20 required Re-revision for Aseptic Loosening***	***95%***

New Acetabular Distraction Data

- Multicenter Retrospective Study
  - Rush University
  - University of Pennsylvania
- All patients underwent Acetabular Distraction for Chronic Pelvic Discontinuity
- January 2002 – December 2013

New Acetabular Distraction Data

- 41 patients identified
  - 6 patients died from unrelated causes
  - 3 patients lost to follow-up
- 32 patients in the final cohort
- Minimum 2-year follow-up (2.1-13.3 years)
  - Bone Loss Classification
    - IIC – 7 (22%)
    - IIIA – 5 (15%)
    - IIIB – 20 (63%)

New Acetabular Distraction Data

- Complications / Failures
  - 1 (3%) patient required revision for cup loosening
  - 2 (6%) patients had radiographic loosening
  - 3 (9%) patients had migration into a more stable position

  - 5 (9%) patients with radiolucencies around the screw holes
  - 11 (34%) patients with radiolucencies around the construct

22 (69%) patients had healing of discontinuity

New Acetabular Distraction Data

New Chronic Pelvic Discontinuity Classification

- I – Jumbo Cup alone
- II – Jumbo Cup + Posterosuperior Augment for Supplemental Fixation
- IIIA – Jumbo Cup + Anterosuperior +/- Posteroinferior Augment for Primary Stability
- IIIB –Jumbo Cup + Augments for Primary Stability and Supplemental Fixation
- IV – Treatment with Jumbo Cup + Augments Utilizing the Dome Technique

- Pelvic Discontinuity Classification for IIIB Defects
  - I – 6 (30%)
  - II – 5 (25%)
  - IIIA – 4 (20%)
  - IIIB – 5 (25%)
  - IV – 0 (0%)

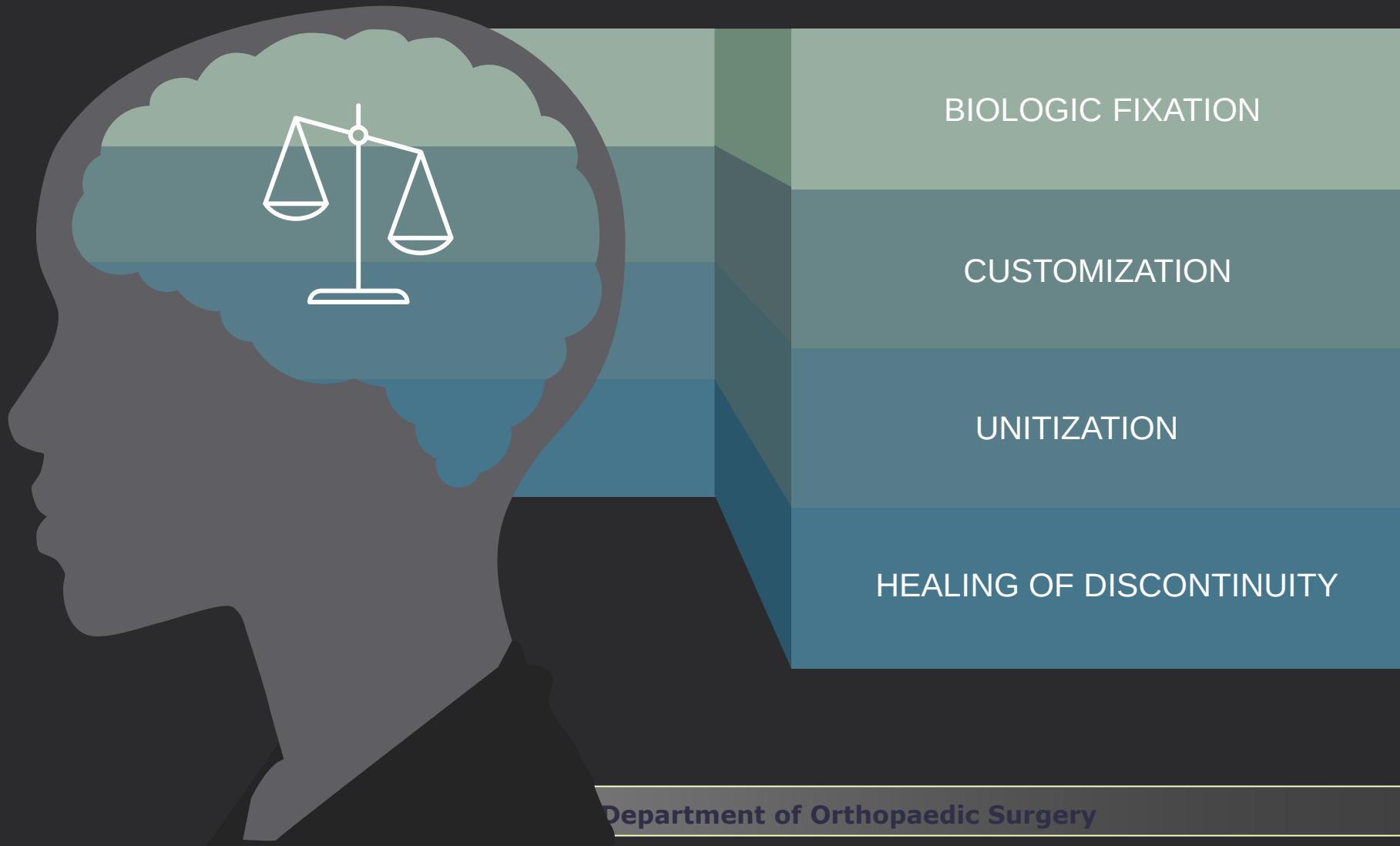
70% of IIIB Defects Required Augments for Reconstruction

Post-operative Management

- 6 -12 weeks of Touchdown (10%) WB
- Advance to 50% WB
- Follow-up at 12 weeks with x-rays
- Advance to WBAT at 18 weeks

- Walker ambulation + **Össur Hip Brace** for 12 weeks

GOAL OF DISTRACTION



Thank You