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Slip angle on preoperative MRI changes Severity Classification of pediatric patients with slipped capital femoral epiphysis

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Disclosures and Biography

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- Medical School 2008-2014, Medical Doctor 2014
- MD PhD 2015-2017, physician-scientist, project title: **Torsional deformities of the hip as a new entity of Femoroacetabular Impingement and Hip Osteoarthritis – from virtual simulation to improved patient outcome**
- Residency:
- 2 years general surgery and orthopedics, 2 years radiology
- Research fellowship Boston Childrens Hospital 2022
- Funding for this study: Swiss National Science Foundation

Related scientific Publications

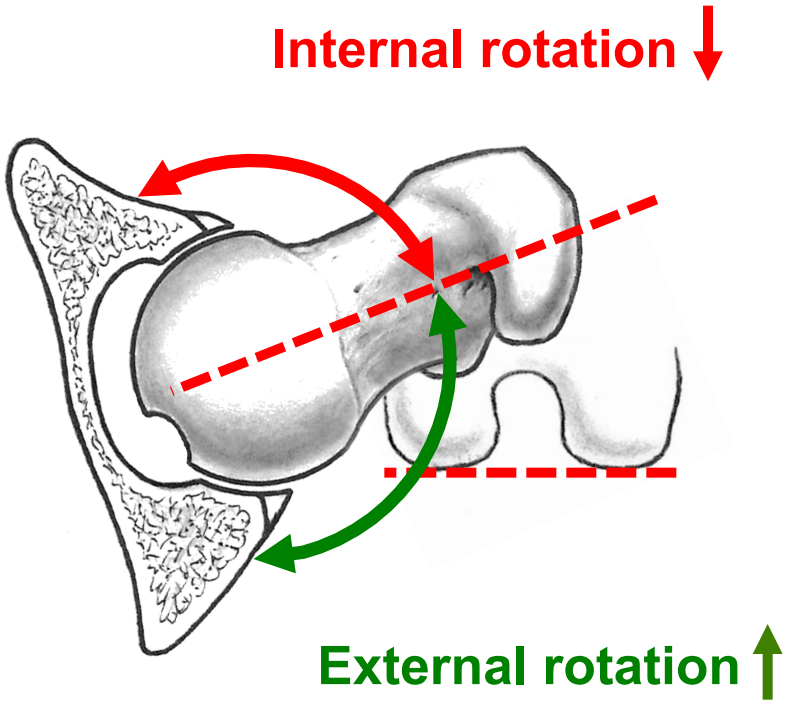
- Automatic bone segmentation to generate MRI-based 3D models for impingement simulation
- Posterior Impingement simulation for patients with increased femoral version
- Anterior Impingement simulation for patients with femoral retroversion

Lerch et al, American Journal of Sports Medicine, ***2019***

Increased FV and Femoral Retroversion

- Normal femoral version:
  10 – 25°
  Tönnis et al, JBJS Am, 1999
- Increased femoral version:
  - Posterior Impingement
  - Extraarticular
- **Femoral Retroversion:**
  - Anterior Impingement
  - Extraarticular

Femoral Retroversion FV<0°



Lerch et al, American Journal of Sports Medicine, ***2019***

Increased FV and Femoral Retroversion

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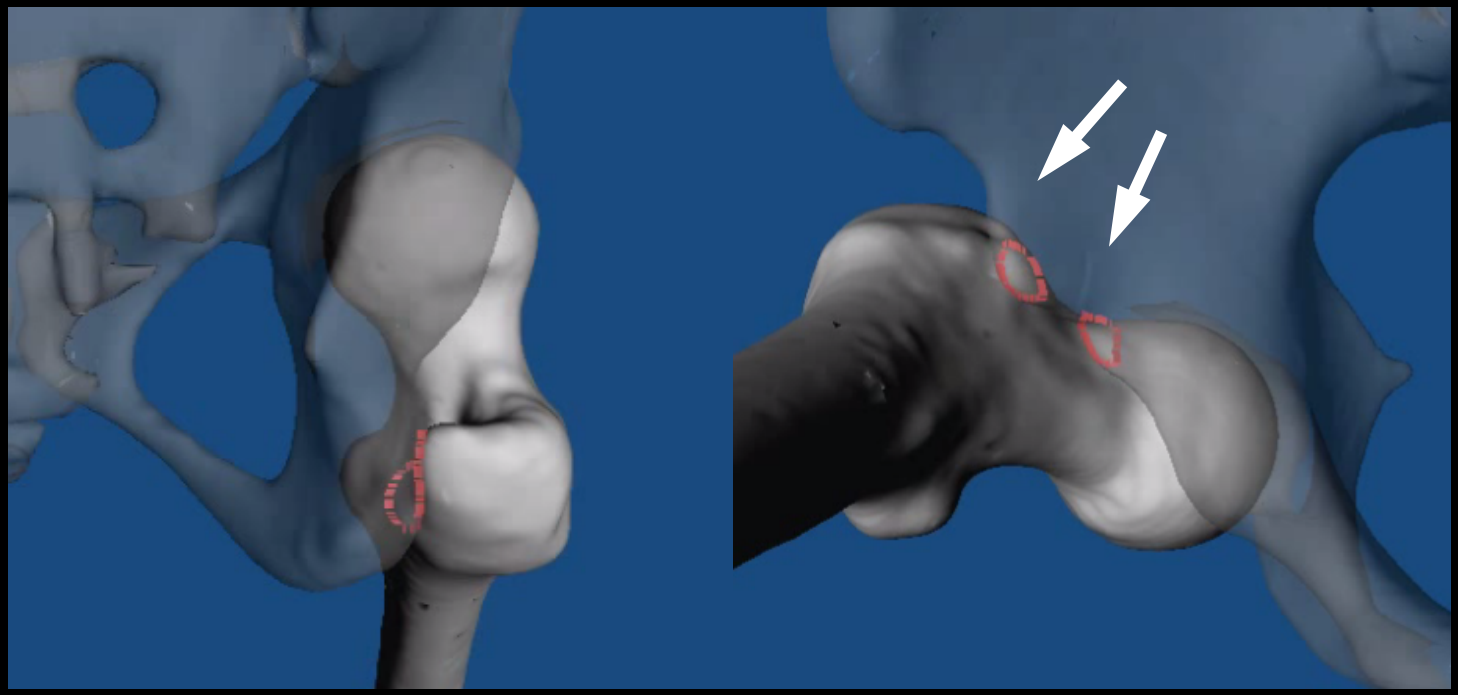
Increased femoral Version

Femoral Retroversion

Extraarticular Impingement



Impingement posterior ischiofemoral

Impingement anterior subspine

Lerch et al, American Journal of Sports Medicine, ***2019***

Introduction

- SCFE is a long-known pre-arthritic hip deformity
- Severe SCFE show inferior and posterior displacement of the capital epiphysis.
- High risk for avascular necrosis of the femoral head (AVN)
- These deformities likely lead to Femoro-acetabular impingement (FAI) and premature osteoarthritis (OA).

Introduction

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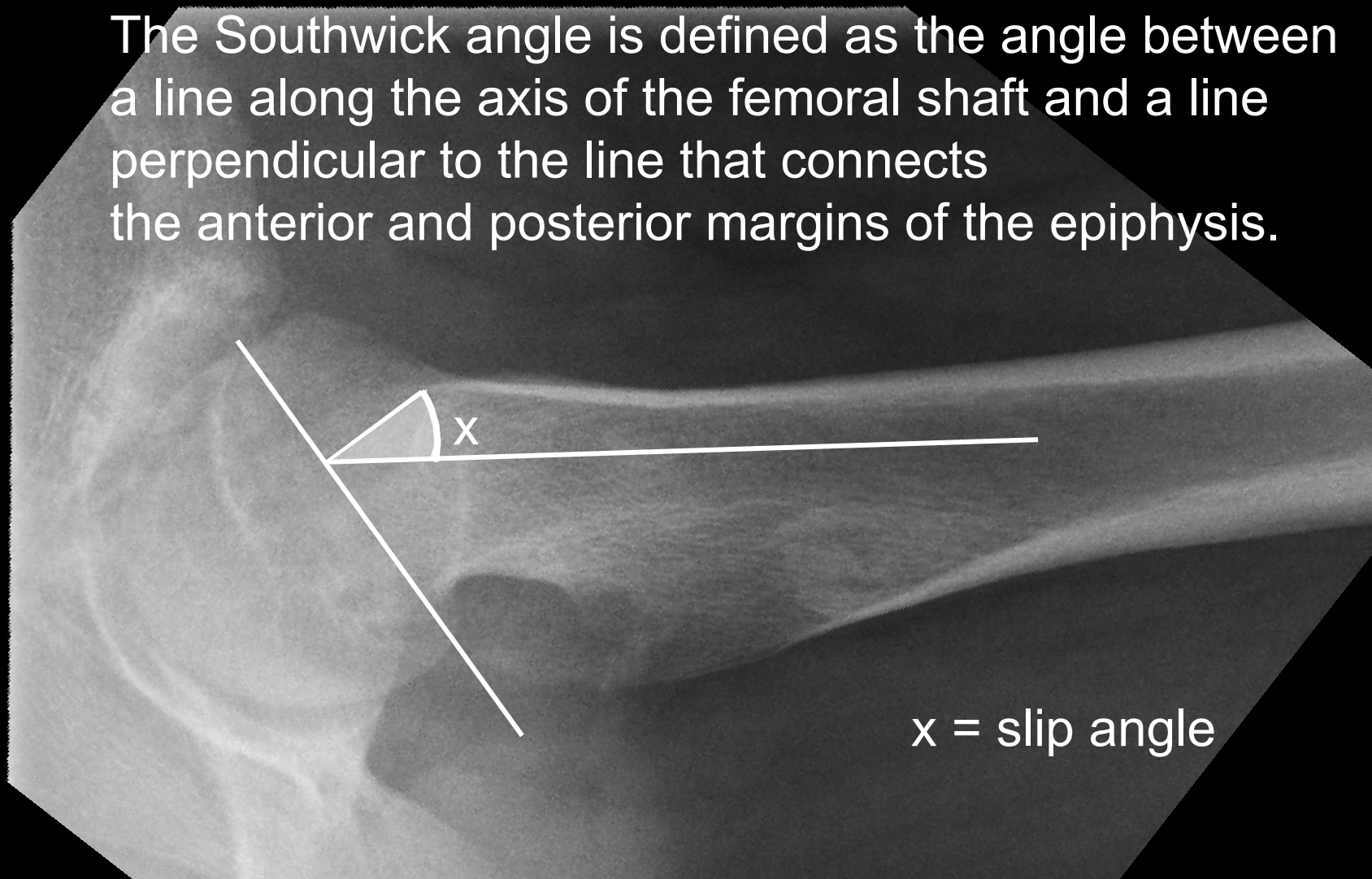
11-year old patient

Slip angle on frog lateral leg position

The Southwick angle is defined as the angle between a line along the axis of the femoral shaft and a line perpendicular to the line that connects the anterior and posterior margins of the epiphysis.



Slip angle measurement

- Biplanar radiograph may underestimate extent of displacement

Monazzam et al, Pediatric Radiology, ***2013***

- Positioning affects SA measurements and SCFE slip severity classifications on frog-lateral radiographs, small errors in positioning could cause >10°errors, consider 3D imaging

Jones et al, Skeletal Radiology, ***2018***

- Computed tomography (CT) scans were considered to be the most reproducible method to measure SA in SCFE

Gelbermann et al, Journal of Bone and Joint Surgery, ***1986***
Richolt et al, Journal of Pediatric Orthopedics, ***2008***
Monazzam et al, Pediatric Radiology, ***2013***
Guzzanti et al, Journal of Pediatric Orthopedics, ***1991***

- Pelvic CT: Considerable radiation exposure (2.9 mSv up to 5.1mSv) and increased lifetime risk of cancer and mortality

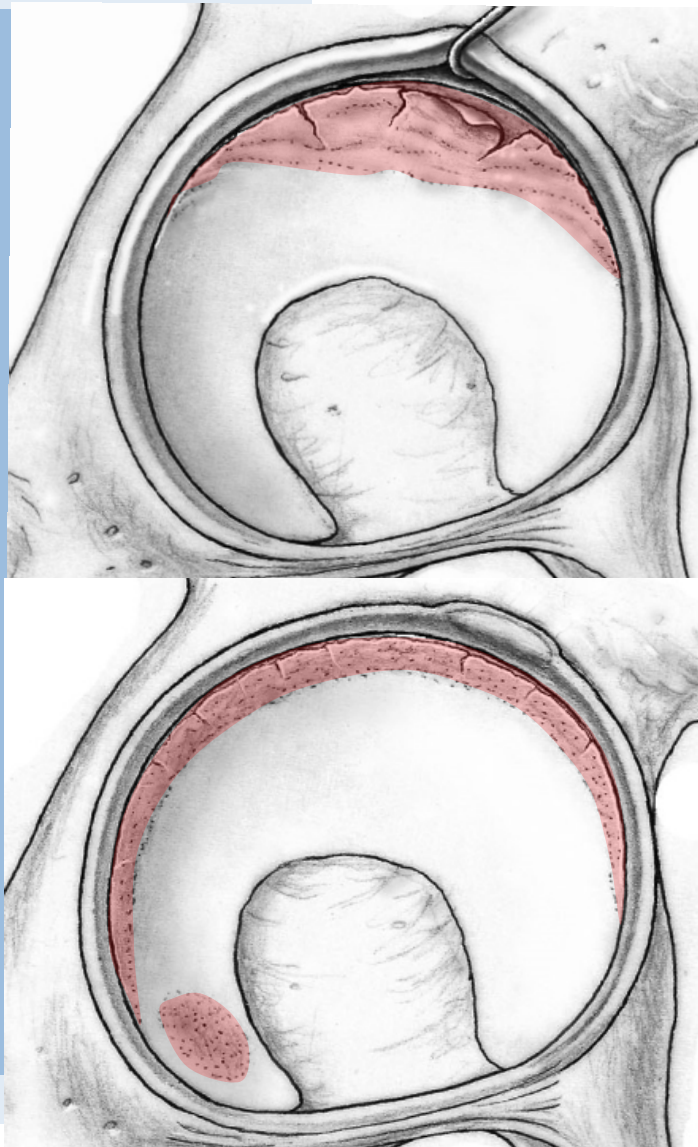
Wylie et al, Arthroscopy, ***2018***

Introduction

- SCFE was associated with Hip Impingement and cartilage damage

- Slip angle measurement is important
  - For diagnosis and classification: mild, moderate or severe SCFE
  - For surgical decision making
  - For prognosis
  - For risk estimation of further hip osteoarthritis

*Tönnis et al, JBJS Am, **1999**,*
*Beck et al, J Bone Joint Surg Br. **2005***
*Tannast et al, Clin Orthop Relat Res. **2008***



Mild SCFE

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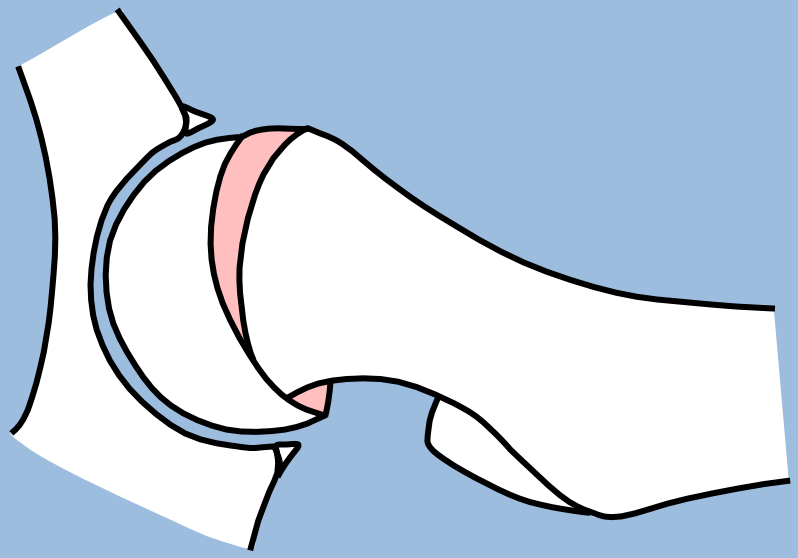
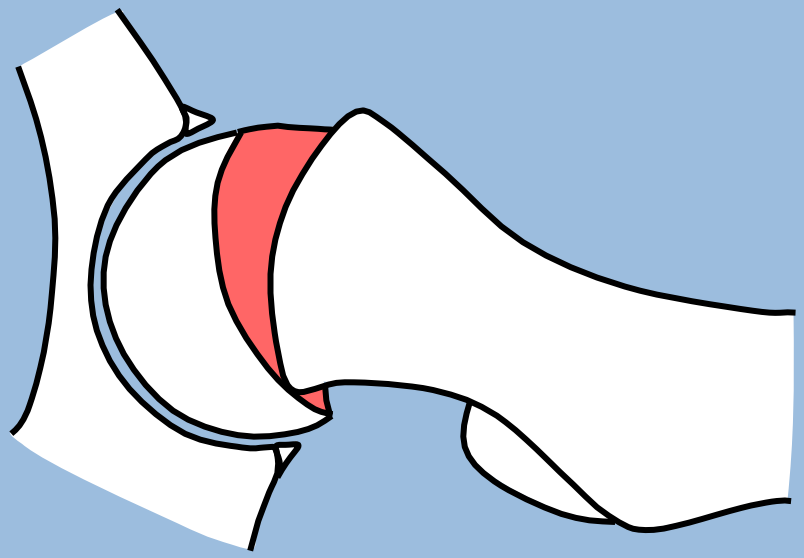
> Mild SCFE



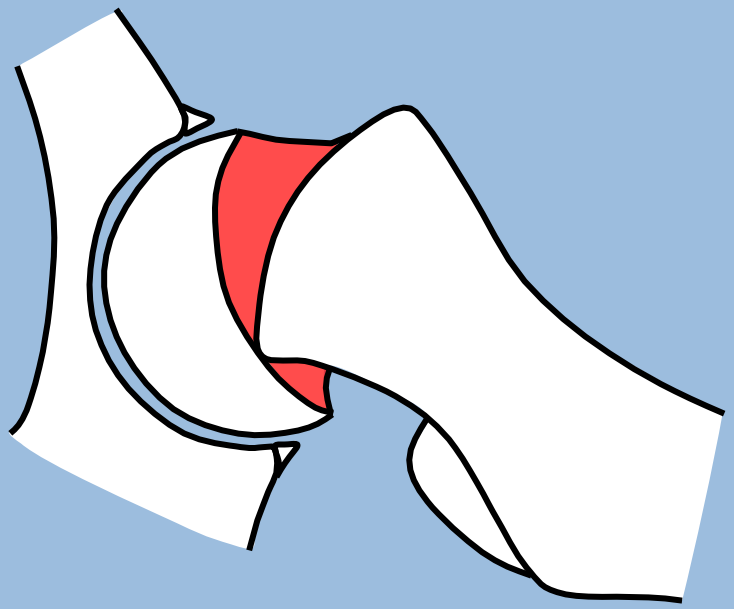
Moderate SCFE

> Moderate SCFE



Severe SCFE

> Severe SCFE



Femoroacetabular Impingement

CLINICAL ORTHOPAEDICS AND RELATED RESEARCH
Number 417, pp. 112–120
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Femoroacetabular Impingement

A Cause for Osteoarthritis of the Hip

Reinhold Ganz, MD*; Javad Parvizi, MD**; Martin Beck, MD*; Michael Leunig, MD*; Hubert Nötzli, MD*; and Klaus A. Siebenrock, MD*

*Ganz et al, CORR, **2003** Dec;(417):112-20*

Introduction: Post-slip deformity

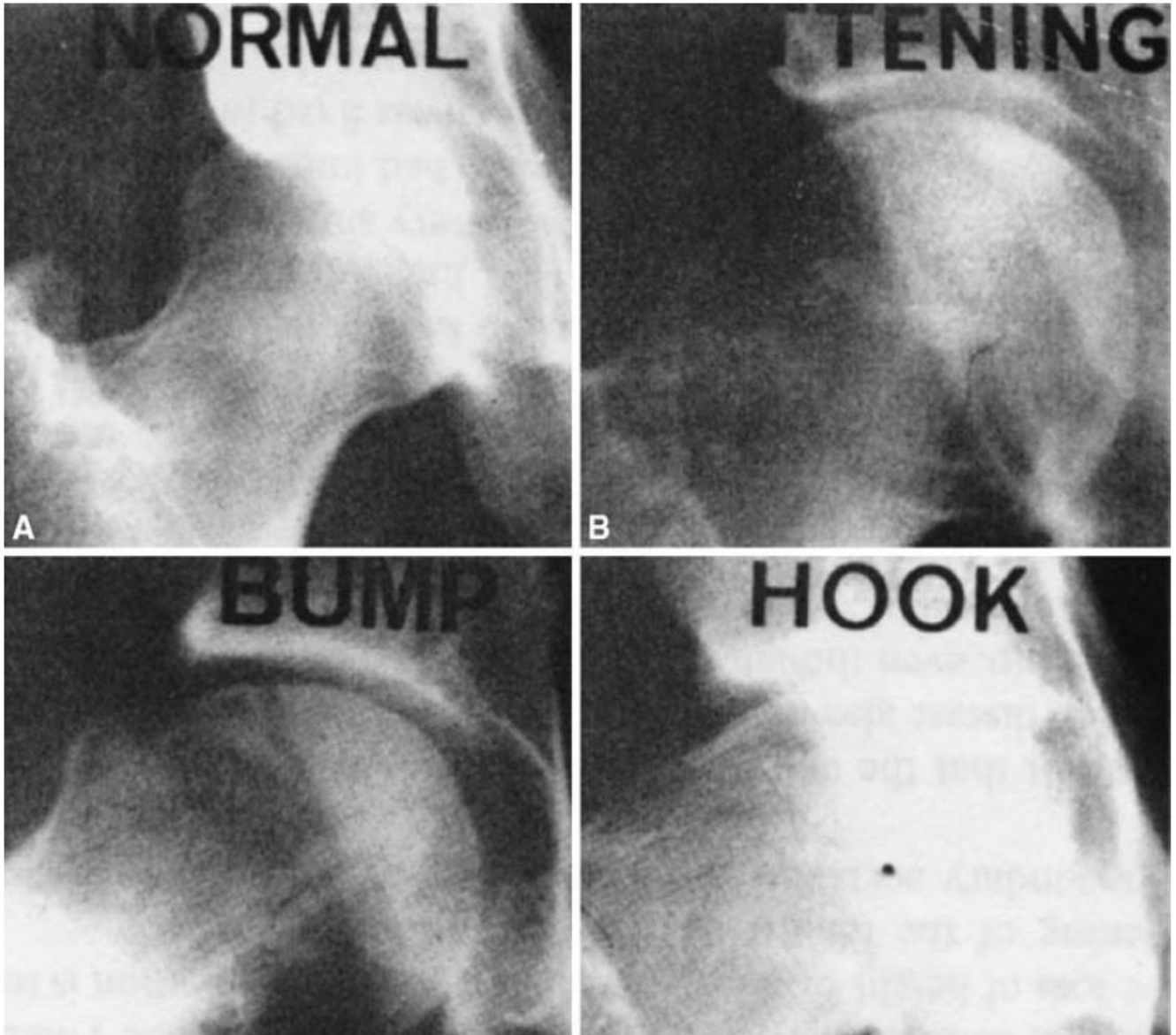
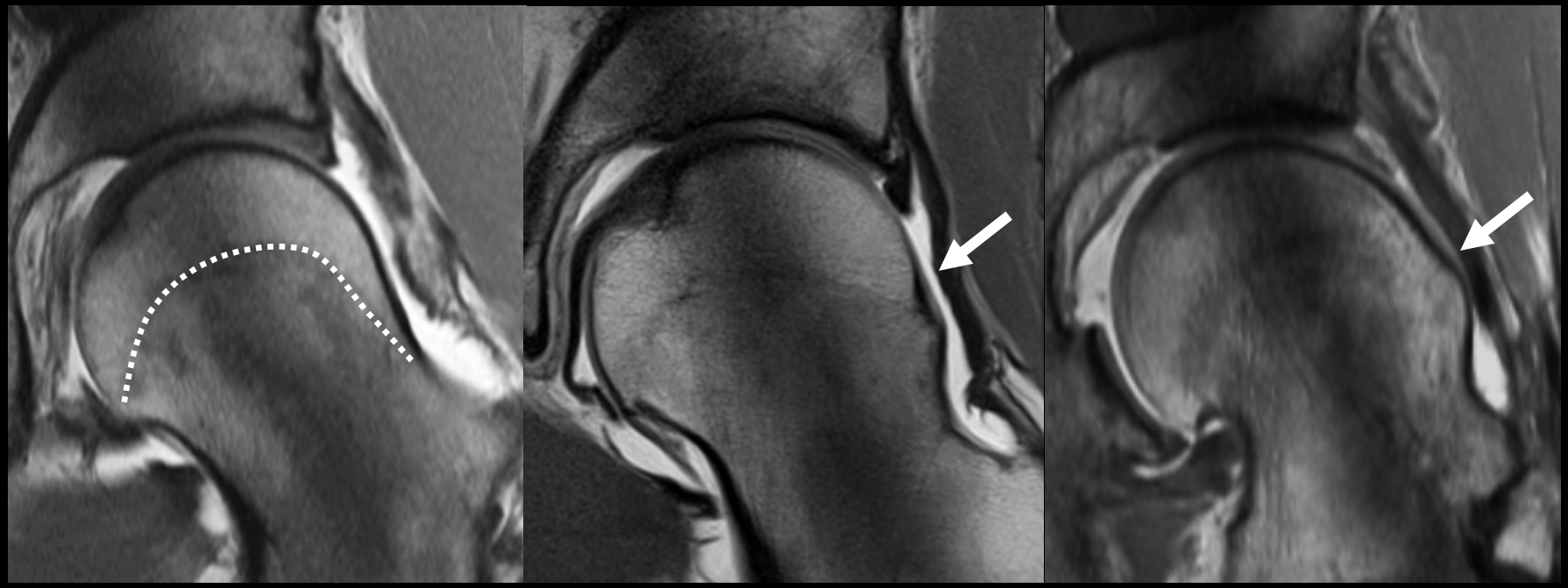


Fig. 1A–D AP radiographs of (**A**) a normal hip and three forms of abnormalities associated with mild slipped capital femoral epiphyses called (**B**) "flattening," (**C**) the "bump," and (**D**) the "hook." Reproduced with permission from Harris WH. Etiology of osteoarthritis of the hip. *Clin Orthop Relat Res.* 1986;213:22.

Introduction: Cam - Impingement

Cam-Type FAI

Idiopathic | Slip-like | Post-slip



*Albers CE et al, CORR, **2015**, 473(4); 1212-23*

Aims

We investigated

- **Measurements of SA on preoperative MRI and on lateral radiographs**
- **Diagnosis and classification and**
- **Direction of slip of SCFE patients.**

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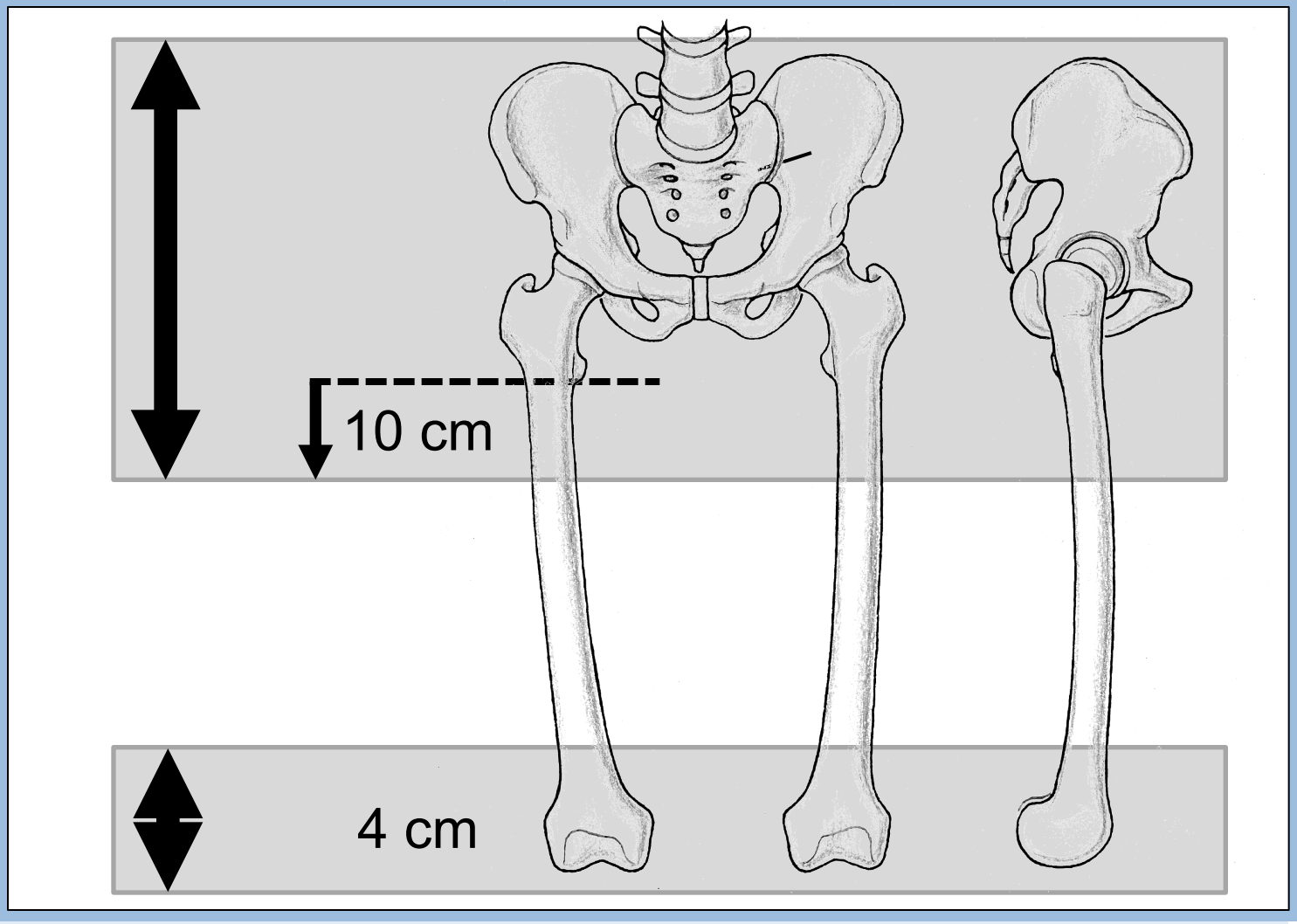
Patients

- Design: Retrospective diagnostic MRI study
- Inclusion criteria: preoperative MRI of SCFE patients
- 29 SCFE patients (31 hips, 2015-2021)
- Mean age was 13±2 years, twelve patients had chronic and 13 patients had acute on chronic SCFE
- Exclusion criteria: SCFE patients with previous surgery, without preoperative MRI or with insufficient radiographs

Tannast et al, J Orthop Res. ***2007*** *;25(1):122-31.*
Steppacher et al, Clin Orthop Rel Res; ***2015****, 473(4):1404-16*

Pelvis MRI T1 VIBE DIXON



Methods

- We evaluated SA on preoperative lateral radiographs and on radial proton-density MRI images of the MRI.
- Radial images were oriented along the axis of the femoral neck.
- The maximum SA on MRI was compared to SA measured on lateral radiograph.
- ICC for maximum SA on MRI was good for two readers. SA was measured on posterior clock positions on MRI.

Radiograph and MRI

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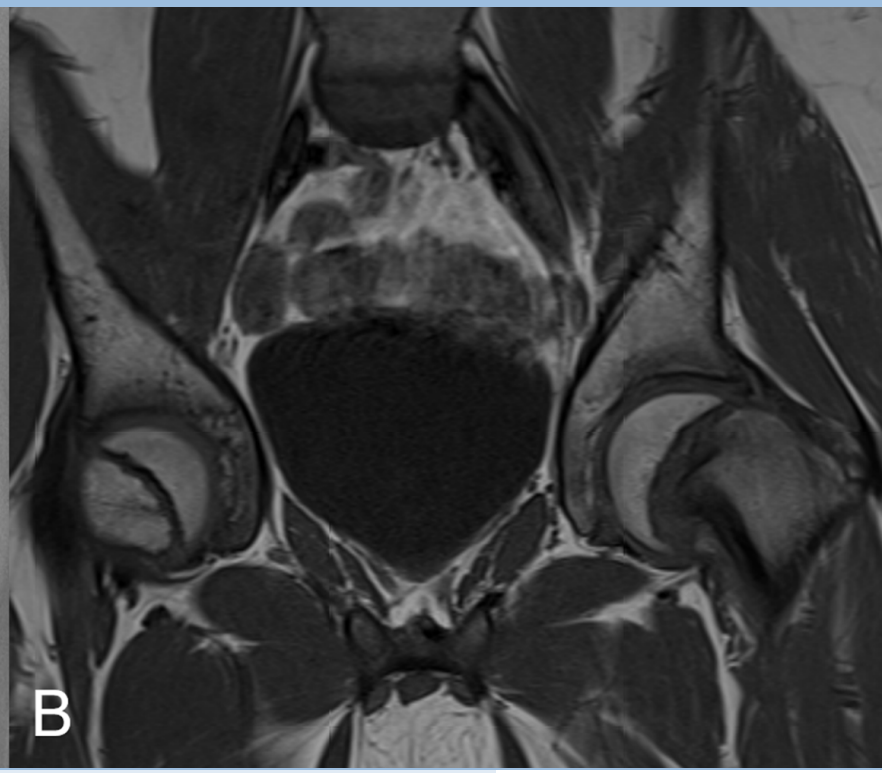

Pelvis MRI T1 VIBE DIXON

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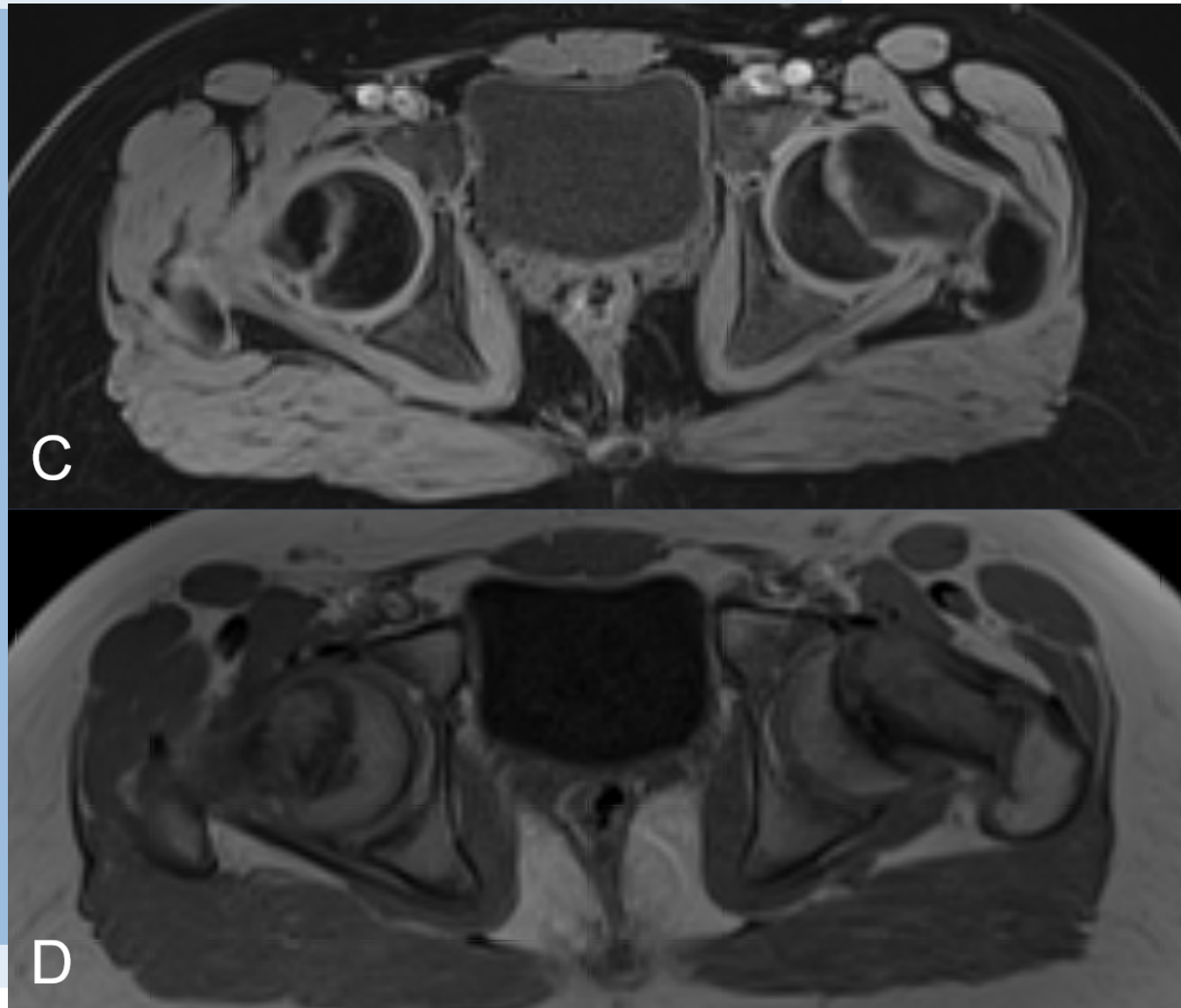
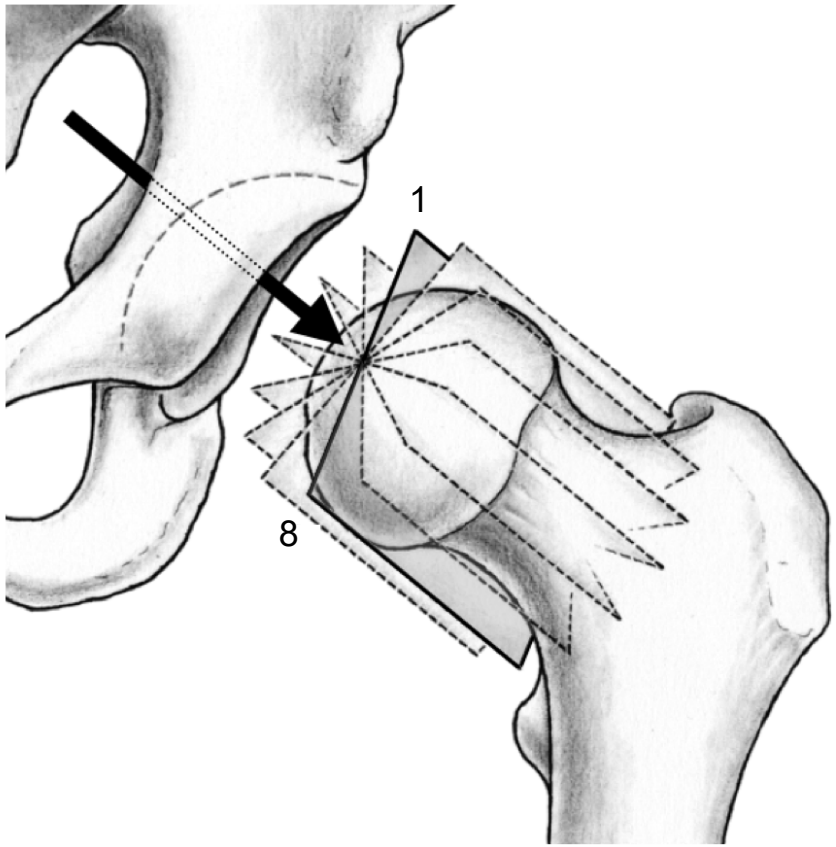
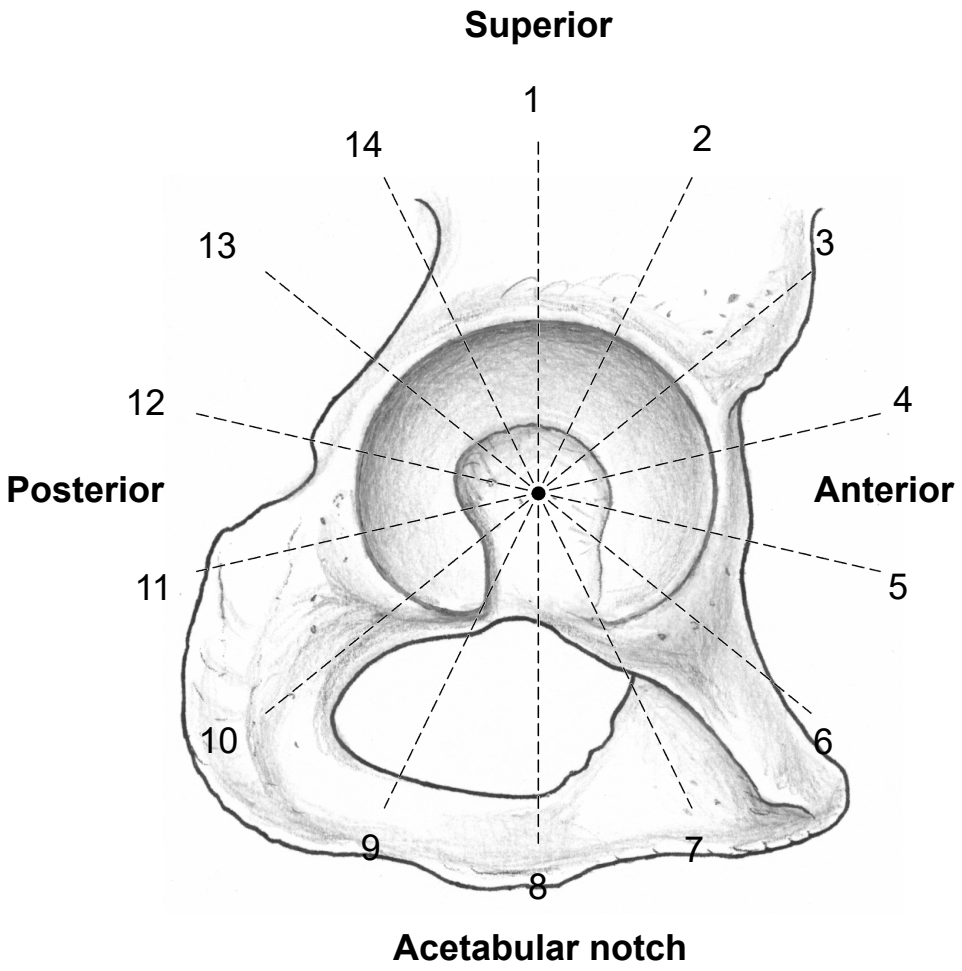
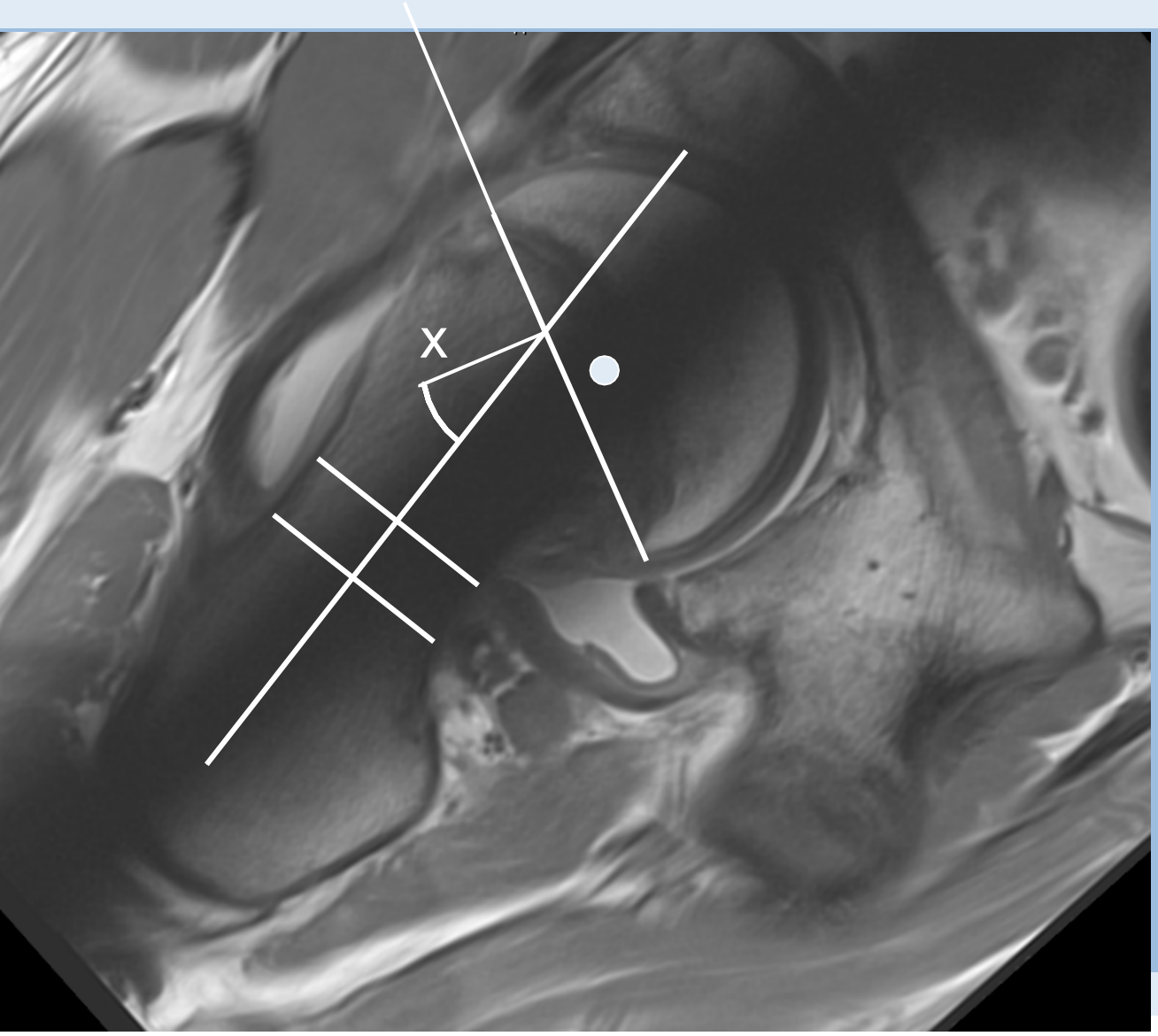


Methods: MRI with radial images





Slip angle on MRI radial images



x = Slip angle

Statistical analysis

- Test for normal distribution
- Independent T-test for mean slip angle
- Chi square test for frequency of mild, moderate and severe SCFE

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Results Slip Angle

- Mean SA on preoperative lateral radiograph was 40±18°, SA on MRI was 48±17°.

- SA on MRI was significantly ($p<0.001$) increased posterior (9 o'clock, 43±18°) compared to superior (12 o'clock, 12±6°) and compared to control group.

Results Diagnosis Classification

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- Measurement of SA on MRI changed diagnosis of 4 patients with severe SCFE,
  six patients had severe SCFE (SA>60°) on radiograph and ten patients had severe SCFE (SA>60°) on MRI.

- Diagnosis changed of 10 patients with moderate SCFE,
  ten patients with mild SCFE (SA<30°) had moderate SCFE (SA 30-60°) on MRI.

Results Slip Direction

- Posterior and posterior-superior (9 o'clock and 10 o'clock) slip direction was most common (29 of 31hips, 94%).

- Whereas none of the hips of the control group (0/30; 0%) had ($p<0.001$) posterior slip.

Limitations

- Small sample size
- Control group of unaffected hip of patients with unilateral SCFE
- Selective patient group from universitary center
  - Limited generalizability

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Summary

- Preoperative MRI can improve diagnosis for SCFE patients, diagnosis changed after MRI of 4 patients with severe SCFE and of ten patients with moderate SCFE.

- Preoperative MRI can be used for surgical planning, especially for stable or chronic SCFE patients.

Conclusion

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- SA measurements on MRI may better inform surgeons to decide when to use in situ pinning (with or without hip arthroscopy for offset correction) or to perform an additional femoral osteotomy for SCFE correction.

- Outlook:
- Patient-specific bony MRI 3D models could be generated and used for collision detection software that may facilitate diagnosis of FAI and surgical planning for SCFE patients.

Poster @ ESPR 2022: MRI-based 3D Model

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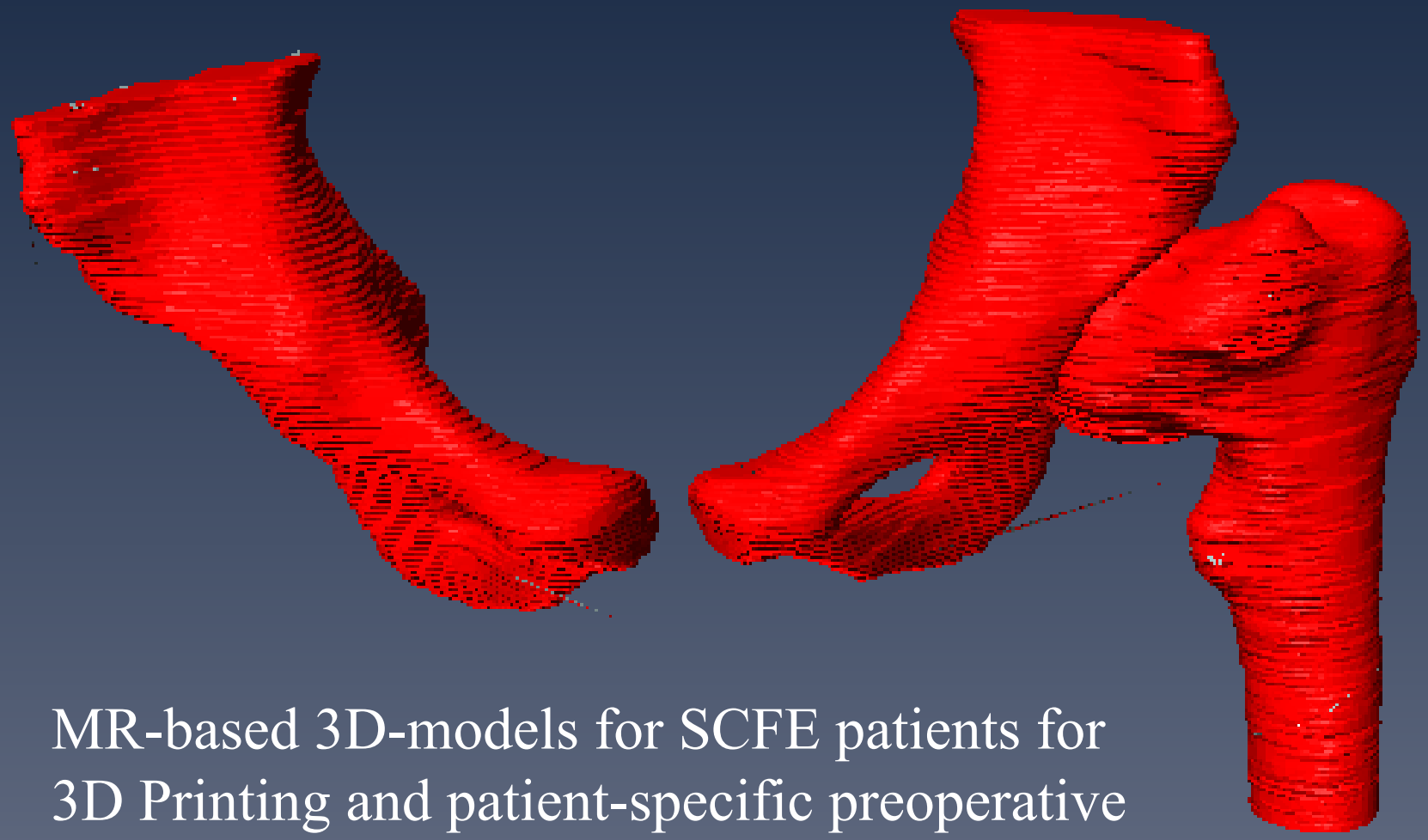

MR-based 3D-models for SCFE patients for 3D Printing and patient-specific preoperative planning of hip preservation surgery

Bilateral Pelvis MRI T1 VIBE DIXON

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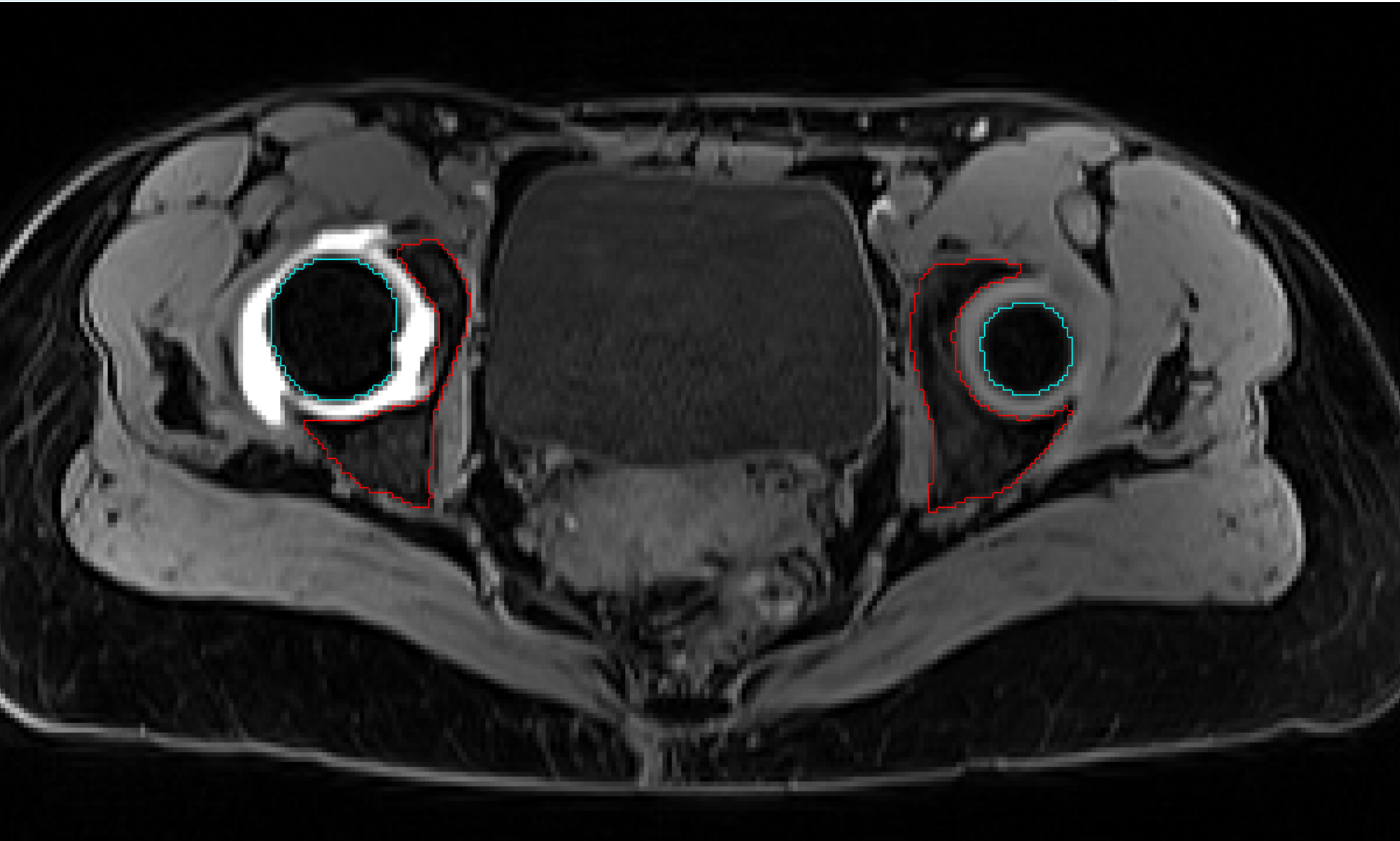

Bilateral Pelvis MRI T1 VIBE DIXON

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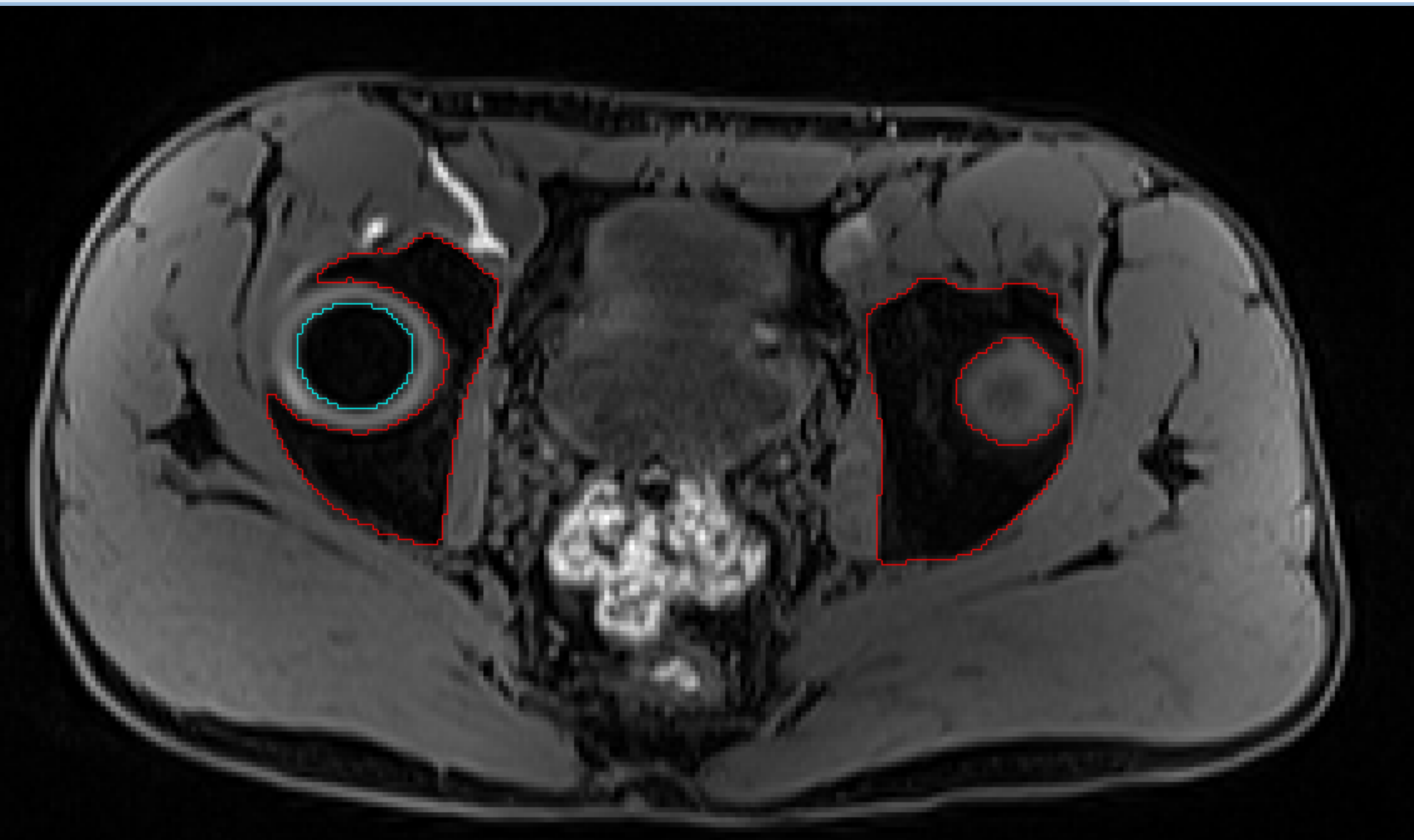

Poster @ ESPR 2022: MRI-based 3D Model

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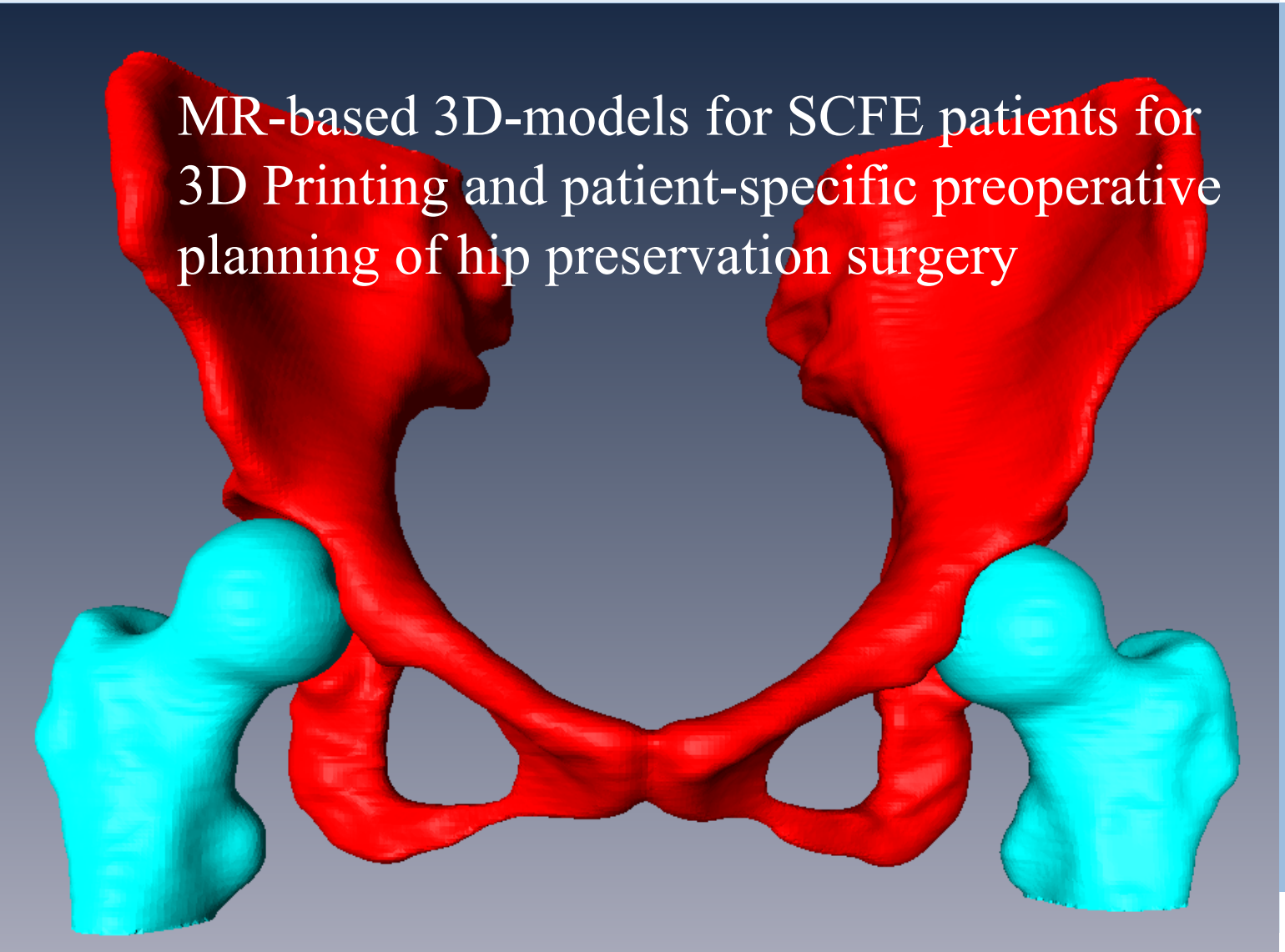

Thank you for your attention

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