FAI Morphologic Variants

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INTRODUCTION
Prox femoral deformity & Arthritis
MURRAY BrJR '65:
• Tilt Deformity
HARRIS CORR '83: Pistol Grip
• 40% Idiopathic Arthritis
GOODMAN JBJS'97
• Subclinical SCFE
• 68% of Cadavers w/ OA
had mild post slip morphology

Femoro-Acetabular Impingement
Definition: Dynamic process in which the proximal femur collides with the acetabular rim or adjacent structures resulting in inflammation and pain

Presents with groin pain (90%) and clinical examination usually with diminished IR and positive provocative impingement (Flexion Adduction Internal Rotation)

Process results in damage to the labrum, reaction or remodeling of bone, and potential cartilage damage
FAI
Initial observations based on acquired deformities

Femoral Neck Non/Malunion (Elger JOrthopTrauma 2001)
Malposition of PAO (Myers CORR 1999)

Femoral Acetabular Impingement - FAI
Morphologies

Femoral Side (CAM)
"Jamming of an abnormal femoral head with increasing radius into the acetabulum"

Acetabulum Side (Pincer)
"the result of linear contact between the acetabular rim and the femoral head neck junction"

Lavinge et al. Anterior Femoroacetabular impingement: Part 1 Techniques for joint preserving surgery CORR 2004

Femoral PathoMorphology
"CAM" deformity

Loss of femoral head sphericity at head neck junction
INTRODUCTION
Assessing CAM deformity

Ito et al Br JBJS’ 01
• Insufficient Head/neck offset extends antero lateral
How to quantify?

Femoral Head Neck Junction
Quantification of morphology
• Angle of sphericity
  – α, β, γ, δ
  – Normal: 42–53°

Toogood et al, CORR, 2009
Nötzli et al, JBJS Br, 2002
Tannast et al, AJR, 2007
Femoral Head Neck Junction

Quantification of morphology
- Angle of sphericity
  - α, β, γ, δ
  - Normal: 42-53°
- Offset
  - Ratio 1:1
  - Maximal waist
  - Alpha reference point

Toogood et al., CORR, 2009
Nötzli et al., JBJS Br, 2002
Tannast et al., AJR, 2007

INTRODUCTION
Axial Oblique MRI – Notzli α angle

Alpha angle dependent on location!

Radial MRI slices in 41 symptomatic hips

<table>
<thead>
<tr>
<th>Plane</th>
<th>Mean (range)</th>
<th>Standard deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anterior</td>
<td>53.4° (9.8°-64.2°)</td>
<td>11.1</td>
</tr>
<tr>
<td>Anterior to 6 o’clock</td>
<td>54.3° (48.3°-66.9°)</td>
<td>11.9</td>
</tr>
<tr>
<td>6 o’clock</td>
<td>61.3° (44.2°-60.3°)</td>
<td>13.4</td>
</tr>
<tr>
<td>12 o’clock</td>
<td>56.7° (42.5°-75.9°)</td>
<td>18.1</td>
</tr>
<tr>
<td>18 o’clock</td>
<td>56.3° (48.7°-68.7°)</td>
<td>14.1</td>
</tr>
</tbody>
</table>

Rakhra et al., CORR, 2009
Alpha angle dependent on age!

- Open growth plate (13 – 15 yrs)
- Athletes vs. Control

Effect of growth plate closure (>13–15 yrs)

- Athletes vs. Control
- Closed vs. Open

Extended physis correlates with alpha angles

- Athletes vs. Control
Influence of age on alpha angle

Cam-type deformities hardly seen before age of 13 or before physeal closure


FEMORAL HEAD ASPHERICITY

Is the Alpha Angle Useful?

Larson et al Arthroscopy ’13
- 125 Football Players (239 hips) of which 75 were symptomatic
- Increasing alpha angle only predictor of hip pain

CAM FAI & Severity of deformity

79% pts w/ CAM FAI have bilateral deformities
ONLY 24% SYMPTOMATIC ON BOTH SIDES

Allen, Beaule et al Br JJBJS ’09
Khanna et al AJSM'14

• 200 Volunteers with mean F/U of 4.4 yrs.
• 170 w/ mean age of 29.5 (77 males/93 females)
• Alpha angle >60° relative risk of 4.3 of getting hip pain

<table>
<thead>
<tr>
<th>Alpha Angle</th>
<th>Follow-up Group</th>
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<th>Alpha Angle</th>
<th>Follow-up Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>89.8 (3.6)</td>
<td>High (&gt;60°)</td>
<td>91.5 (3.8)</td>
<td>Normal</td>
<td>89.8 (3.6)</td>
</tr>
<tr>
<td>Head Tilt</td>
<td>90.9 (3.3)</td>
<td>Normal</td>
<td>89.8 (3.6)</td>
<td>Normal</td>
<td>89.8 (3.6)</td>
</tr>
</tbody>
</table>

FEMORAL HEAD ASPHERICITY

Is the Alpha Angle Useful?

Hack et al JBJS 10:

200 Volunteers (400 Hips)

State w/ some certainty that cutoff values must be used in Dx CAM FAI

• 3 O’clock > 50 degrees
• 1:30 Position > 60 degrees

Sutter et al Radiology’12

• 55°α angle sensitivity & specificity of 86% & 56%
• 60°α angle sensitivity & specificity of 76% & 74.5%

FEMORAL HEAD ASPHERICITY

Alpha Angle of Notzli & Multi-planar

Potential contributing factors, Femur

Tilt, torsion, varus/valgus: multiple may exist in an individual

Normal Torsion

Head Tilt

Abnormal Torsion

Complex deformities
Neck-shaft angle (CCD angle)

Neck-shaft angle: 120 – 135°
Large variations up to 40°
Decreases with age during growth

Hefti, Kinderorthopädie, 2015,
Toogood et al, CORR, 2009

Femoral Morphology
Acquired Tilt - SCFE

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Femoral Morphology - FAI

Femoral Torsion

LCE 28°
AI 0°
PW -
CCD 126°
Cranial retro

Femoral Morphology - FAI

Femoral Torsion

LT: Posterior
α Angle = 45
Normal offset

Retrotorsion -10

Lateral
R

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Acetabular Morphologies: FAI

Abnormal shape

Malorientation

Acetabular abnormalities

Abnormal shape
  – Global overcoverage
  – Segmental overcoverage

Malorientation
  – Retroversion

Pincer impingement

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Acetabular abnormalities

Abnormal shape
- Global overcoverage
  - Coxa profunda
  - Protrusio
- Segmental overcoverage
  - Anterior-superior
  - Prominent inferior spine
  - Posterior

Malorientation
- Retroversion

I. Global overcoverage

Coxa profunda  Protrusio
II. segmental overlap – overcoverage?

antero-superior
- typically < upper third of acetabulum
- needs quantification of coverage
  - anterior
  - posterior
- rule out prominent inferior spine

Substantial retroversion > one third

Retroversion index:

segmental overlap

subspine impingement (prominent ASIS)

oblique views
CT/MRI scans

difficult to judge intraop decision
Pathomorphologies

- global
- segmental
- Malorientation

Acetabular retroversion

- Malorientation
  - cross-over sign
  - posterior wall sign
  - ischial spine sign

Acetabulum Morphology - FAI

**Area size of lunate surface**

![Image of area size of lunate surface chart]

- Normal
- Dysplasia
- Retroversion
- Deep
- Protrusio

Relative size of the lunate surface (%)
- 10%
- 20%
- 30%
- 40%
- 50%
- 60%

- $p < 0.001$
- $p < 0.001$
- $p < 0.001$
- $p = 0.657$

**Femoral Morphology - FAI**

- Mixed
  (may represent the majority of cases)

**Hip Pathomorphologies: FAI**

Symptomatic Presentation

Many differing anatomic variations can cause hip pain

Thorough exam and systematic review of the radiographs will allow for a proper diagnosis and individualization of treatment.