Hip Deformity in the Young Adult: Scope or Open?

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California Orthopaedic Association Annual Meeting
5/21/17
Agenda

• Mechanical Spectrum of Hip Disease
• Hip Dysplasia
• Femoroacetabular Impingement
• Choices in Treatment & Outcomes
Structural Abnormalities Associated with Premature Hip Joint Failure

Of 337 hips (<50 yo; avg age 40) undergoing THA for “OA”:

• Dysplasia 48.4%
• Perthes Disease 9.5%
• Slipped Epiphysis 6.2%
• “Other” FAI 35.9%
  • CAM FAI - 62.8%
  • Pincer FAI – 6%
  • Combined FAI – 30%

(Clohisy et al, JBJS 2011)
National History of OA in Dysplasia & Impingement

Wyles et al, CORR 2016
- Analyzed contralateral hip in THA patients <55yo
- Mean 20-year followup
- 172 patients (48 DDH, 74 FAI, 40 nl)
- THA in 33% DDH, 18% FAI, 15% nl
- Earliest degeneration in DDH, DDH with CAM
Mechanical Etiology of Hip Osteoarthritis

• Problems of Instability & Impingement
• Mechanical behavior of the hip is different from anatomy of the hip
  • Anatomy of the hip shows us risk factors for the hip’s behavior
  • Behavior = Actual disease = Dynamic, mechanical disorder
  • Mechanical disorder causes structural damage
Labral Tear
Labral Tears

- Labral tears rarely occur in the absence of a bony structural abnormality!

### TABLE 4. Percentage of Patients with Labral Tears of the Hip with Structural Abnormalities

<table>
<thead>
<tr>
<th>Patients (%) n = 31</th>
<th>95% CI</th>
<th>Number of Structural Abnormalities</th>
</tr>
</thead>
<tbody>
<tr>
<td>27 (87%)</td>
<td>70–96</td>
<td>1 or more</td>
</tr>
<tr>
<td>11 (35%)</td>
<td>19–55</td>
<td>2 or more</td>
</tr>
<tr>
<td>16 (52%)</td>
<td>33–70</td>
<td>1</td>
</tr>
<tr>
<td>10 (32%)</td>
<td>17–51</td>
<td>2</td>
</tr>
<tr>
<td>1 (3%)</td>
<td>0.1–16</td>
<td>3</td>
</tr>
</tbody>
</table>

CI = confidence interval
Example: Hip Dysplasia Causing Labral Tear
Example: Femoroacetabular Impingement Causing Labral Tear
Principles: Hip Mechanical Equilibrium

Instability

Activity level

Impingement

Time
Hip Dysplasia: Adolescence & Young Adulthood

• Presentation:
  • Female (80-90%)
  • Activities requiring flexibility
  • Childhood DDH
  • >50% with Family history of hip disease (i.e. DDH, OA by age 65)

Lee et al, JPO 2013
Symptoms:

- Insidious onset (97%)
- Activity-related (88%)
- Anterior/groin (72%) or lateral (66%) hip pain
- Mechanical symptoms (instability, catching)

Nunley et al, JBJS 2011
Hip Dysplasia: Adolescence & Young Adulthood

- Physical Exam Signs:
  - Hypermobility
  - Pain with hip flexion
  - + Anterior impingement test (97%)
  - + Anterior apprehension test
  - + Limp (48%)
  - + Trendelenberg (38%)

Nunley et al, JBJS 2011
Activity Level and Severity of Dysplasia Predict Age at Bernese Periacetabular Osteotomy for Symptomatic Hip Dysplasia

Travis Matheney, MD, Ira Zaltz, MD, Young-Jo Kim, MD, PhD, Perry Schoenecker, MD, Michael Millis, MD, David Podeszwa, MD, David Zurakowski, PhD, Paul Beaulé, MD, and John Clohisy, MD, on behalf of the ANCHOR Study Group

JBJS 2016

- Independent predictors of age of presentation for PAO:
  1. Severity of dysplasia
  2. Activity level
Dysplasia: Abnormal Anatomy

- Acetabulum volumetrically deficient
- Decreased lunate cartilage size
- Decreased cotyloid fossa size
- May be related to insufficient growth of lateral acetabular epiphyses during adolescence

Pun et al, CORR 2017
Steppacher et al, Osteoarthritis and Cartilage, 2014
Tonnis et al, JPO 2004
Dysplasia: Abnormal Anatomy

AP Pelvis

Normal LCEA > 25°
Dysplasia < 20°

Normal Tönnis Angle < 10°
Dysplasia > 10°

Lee et al, Orthop Clin North Am 2012
Dysplasia: Abnormal Anatomy

Normal ACEA > 25°
Dysplasia < 20°

Lee et al, Orthop Clin North Am 2012
Dysplasia: Altered Mechanics

- Decreased contact area – 26% smaller
- Increased shear stress
- Higher mean peak contact stress
- Higher mean cumulative contact stress
- Cumulative contact stress predicts early hip OA better than LCEA
- Same prevalence of OA
  - Dysplastic @ age 51
  - Normal @ age 68
- Linear extrapolation: control hips would achieve dysplastic-level cumulative contact stress at age 90 years

Hipp et al, CORR 1999
Zhou et al, J Orthop Sci 2010
Mavcic et al, CORR 2008
Effects of Abnormal Mechanics on Intra-Articular Structures

- Rim Overload Syndrome
  - Mechanically unfavorable environment at the acetabular rim
- Labral hypertrophy on MRI
- Labral tear

Klaue et al, JBJS(Br), 1999
Leunig et al, CORR 2004
Effects of Abnormal Mechanics on Intra-Articular Structures

- Cartilage biochemical changes
  - Cartilage hypertrophy at rim
  - Decreased GAG content

Niknafs et al 2013
Kim et al, JBJS 2003
Effects of Abnormal Mechanics on Intra-Articular Structures

- Osseous changes (Gothic arch tilted, subchondral cysts)
- Rim Overload Syndrome $\rightarrow$ rim fractures

Klaue et al, JBJS(Br), 1999

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Why Care About Hip Dysplasia?

1. Dysplasia has a poor natural history
   • Early Hip OA
   • Untreated dysplasia causes years of lost function, pain, decreased productivity, depression and social isolation in young, active population

Ackerman et al, Osteoarthritis and Cartilage, 2015
Why Care About Hip Dysplasia?

2. We can change the natural history with surgical treatment
   • Periacetabular Osteotomy (PAO)

Gurd, DP: Late-presenting developmental dysplasia of the hip. Orthopaedic Knowledge Online Journal 2009
Why Care About Hip Dysplasia?

2. We can change the natural history with surgical treatment
   • Periacetabular Osteotomy (PAO)
PAO to Correct Acetabular Dysplasia with Subluxation

**Before**
- Subluxated Right Hip
- Negative LCEA
- Short Right Leg

**After**
- Joint is reduced & medialized
- Femoral head is covered
- Leg lengths equalized

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PAO to Correct Acetabular Dysplasia with Subluxation

Before

After
PAO: Mechanical Effects

- Increased load-bearing area after PAO
  - Preop 7.2 cm²
  - Postop 11 cm²
PAO: Mechanical Effects

- Normalization of cartilage loading and stress
PAO: **Modern Approach**

- Small “bikini” incision
- Hip abductor- and Rectus-sparing approach
- Transexamic acid & Cell saver
- Regional nerve block
- Local iliac crest bone grafting
- 3-4 days in hospital
- Ambulatory on POD 1
Activity Level after PAO

  - 33 month avg FU
  - 71% return to presurgical or higher activity levels after PAO
  - Significant improvements in Harris Hip, HOOS, WOMAC scores
Example: 12yo Female Softball Player with Bilateral Acetabular Dysplasia
Acetabular Dysplasia: PAO Outcomes

- Kaplan-Meier Freedom from THA
  - 5 Years: 96% (95% CI: 93 - 99%)
  - 10 Years: 84% (95% CI: 77 - 90%)

- Years From PAO
  - 5 years: 95% (95% CI: 91-99%)
  - 10 years: 85% (95% CI: 79-92%)
  - 15 years: 80% (95% CI: 73-88%)
  - 18 years: 74% (95% CI: 66-83%)

Matheney et al, JBJS 2009; Wells et al, CORR 2016
Acetabular Dysplasia: PAO Outcomes

Preoperative osteoarthritis score according to Tönnis [51] (%)

- Grade 0: 43
- Grade 1: 33
- Grade 2: 21
- Grade 3: 3

• Tonnis 2 & 3: 24%
Acetabular Dysplasia: PAO Outcomes

A

- Survival Rate (%)
- Followup (years)
- Age categories: < 20 Years, < 30 Years, > 25 Years, > 35 Years, > 40 Years, > 45 Years

B

- Survival Rate (%)
- Followup (years)
- OA categories: OA = 0, OA = 1, OA ≥ 2
Complex Anatomy: Dysplasia and FAI Anatomy Often Coexist

- >70% have decreased femoral head/neck offset
- 66% of symptomatic hips have 2 or more impingement parameters

<table>
<thead>
<tr>
<th>Impingement factors</th>
<th>Number of hips</th>
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<tr>
<td></td>
<td>Instability factors</td>
</tr>
<tr>
<td></td>
<td>0</td>
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<td>0</td>
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</tr>
<tr>
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<td>2</td>
<td>13</td>
</tr>
<tr>
<td>3</td>
<td>18</td>
</tr>
<tr>
<td>4</td>
<td>10</td>
</tr>
<tr>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>55 (49.1%)</td>
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</table>
Dysplasia with FAI Deformity

- MRI

<table>
<thead>
<tr>
<th>Tear:</th>
<th>frequent</th>
<th>frequent</th>
<th>frequent</th>
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<tr>
<td>Vol. increase:</td>
<td>frequent</td>
<td>frequent</td>
<td>no</td>
</tr>
<tr>
<td>Ganglia:</td>
<td></td>
<td></td>
<td>rare</td>
</tr>
</tbody>
</table>

Leunig et al, CORR 2004
Dysplasia with FAI Deformity

• Important to identify the primary mechanical problem in the hip

• Implications for PAO correction:
  • Impingement from acetabular retroversion can be produced if uncorrected
  • Asymptomatic CAM deformity may be unmasked after increasing acetabular coverage
  • Higher expectation for need for concomitant procedures (arthroscopy, arthrotomy)
Example: Dysplasia with FAI anatomy

• 32yo M with bilateral L > R hip pain worse with upright, weight-bearing activity
• “Always been flexible”, martial artist
• +Family Hx: Mother had hip dysplasia and early THA
• +Anterior apprehension test
Example: Dysplasia with FAI anatomy
Example: Dysplasia with FAI anatomy
Treated with PAO & Arthrotomy for Femoral Osteochondroplasty
Example: Dysplasia with FAI anatomy
Treated with PAO & Arthrotomy for Femoral Osteochondroplasty
Residual Deformity after Childhood DDH Treatment

- 16yo F competitive tennis player with childhood left DDH
- Prior closed reduction, femoral osteotomy, Pemberton osteotomy
- Now pain with walking, running, sitting
Residual Deformity after Childhood DDH Treatment
Residual Deformity after Childhood DDH Treatment

• Diagnosis:
  • Residual Acetabular Dysplasia
  • Acetabular Retroversion
  • Subspine Impingement (AIIS)
Residual Deformity after Childhood DDH Treatment

• Treatment:
  • Left PAO
    • Increased lateral coverage
    • Increased acetabular anteversion
  • AIIS Recession
Subspine Impingement: Before and After PAO with AlIS Recession
L PAO with AllS Recession: Preop and Postop
Improved Version, Sourcil Obliquity, AllS
Improved Joint Congruency
Improved Joint Congruency
Caution: Arthroscopic Treatment of Dysplasia

• Parvizi et al, J Arthroplasty 2009
  • 34 dysplastic hips (LCEA <20) underwent hip arthroscopy for labral tear
  • 24 persistent pain
  • 14 accelerated arthritis
  • 13 femoral head subluxation
  • @ 3.5 yr avg followup: 3 THA, 6 PAOs

• Ross et al, J Arthroplasty 2014
  • Characteristics of 30 dysplastic hips that failed hip arthroscopy:
    • LCEA 14.7
    • Tonnis angle 16.3
    • ACEA 16.8
Caution: Arthroscopic Treatment of Dysplasia

• Larson et al, Am J Sports Med 2016:
  • Scopes in patients with LCEA < 20 had smaller gains in clinical scores and higher failure rate when compared to FAI comparison cohort
  • Better results if labral repair and capsular plication performed
Caution: Arthroscopic Treatment of Dysplasia

- Recall: Natural history of DDH is to develop OA
- Risk factors:
  - LCEA < 25
  - Tonnis angle > 8
- Arthroscopy cannot normalize femoral head coverage or sourcil obliquity

Progression from 0 to 3 or THA

Relative Risk of Progression

Lateral Center-edge Angle

Wyles et al, CORR 2016
Example: 27yo F with right acetabular dysplasia and recurrent pain 8 months after hip arthroscopy
Example: 27yo F with right acetabular dysplasia and recurrent pain 8 months after hip arthroscopy
Treatment: Right PAO

Before

After
Treatment: Right PAO

Before

After
PAO with Concomitant Hip Scope: Outcomes

• Controversy regarding necessity for intra-articular work

• Current Indications:
  • Mechanical symptoms consistent with labrochondral separation

• Potential benefits:
  • Better view and ability to repair labrum
  • Prognosticate PAO outcome
  • Treat CAM deformities
  • Prevent residual hip pain

• Kim et al, JBJS Br 2011
  • 43 PAOs with concomitant hip scope
  • Labral lesions in 38 hips
  • Mean followup 6 years
  • Harris Hip Score improved from 72.4 to 94.0
  • No control group
Example:
27yo F with Right Acetabular Dysplasia, Associated Rim Fracture & Labral Tear
Example:
27yo F with Right Acetabular Dysplasia, Associated Rim Fracture & Labral Tear
Example:
27yo F with Right Acetabular Dysplasia, Associated Rim Fracture & Labral Tear
Example:
Right Acetabular Dysplasia, Associated Rim Fracture & Labral Tear: Treated with combined PAO & Hip Scope

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Torn, hypertrophic acetabular labrum

After repair of labral tear
Example:
Right Acetabular Dysplasia, Associated Rim Fracture & Labral Tear: Treated with combined PAO & Hip Scope

Before

After
Example:
Right Acetabular Dysplasia, Associated Rim Fracture & Labral Tear: Treated with combined PAO & Hip Scope

5 months postop: mountain biking, running pain-free
Hip Dysplasia: Role of Arthroscopy

• Real questions:
  • Do we need to address the intra-articular damage?
  • After PAO, how many and which hips are symptomatic from labral tears?
  • Can we predict who will be symptomatic, so that we can plan for combined PAO with scope?

• For now, PAO is still gold standard
  • PAO corrects underlying mechanical problem
  • Avoid scope in LCEA < 20-25, Tonnis angle > 8-10
  • Consider scope if +mechanical symptoms
  • If scope borderline dysplasia, follow patients closely
    • If recurrent pain after scope, then PAO before cartilage degeneration occurs
Principles: Hip Mechanical Equilibrium
Femoroacetabular Impingement (FAI)

• Presentation:
  • Male & female
  • Family history of OA

• Symptoms:
  • Insidious onset
  • Anterior/groin or lateral hip pain, worse with flexion
  • “Stiff/tight”; not flexible
  • Mechanical symptoms (catching, locking)
Femoroacetabular Impingement (FAI)

• Physical Exam Signs:
  • Limited flexion > IR > abd
  • Passive IR <<< ER
  • + Anterior impingement test
  • Pain with hip flexion

Leunig et al, JBJS 2001

Dysplasia and FAI can Present Similarly!

• Similarities:
  • Anterior hip/groin pain
    • 72% AD vs 83% FAI
  • Pain with hip flexion
  • + Anterior impingement test
    • 97% AD vs 88% FAI
  • + Limp
  • + Trendelenberg

• Differences:
  o Dysplasia:
    • Hypermobility
    • + Anterior apprehension test
  o FAI:
    • Decreased hip flexion & IR

Clohisy et al, CORR 2009; Nunley et al, JBJS 2011
Femoroacetabular Impingement (FAI)

- Chronic impingement with motion causes mechanical damage to the acetabular rim and adjacent cartilage

[Diagram showing normal, CAM, pincer, and mixed types of FAI with pinching of labrum]
Rationale for Impingement-Relieving Surgery

• Mechanical “conflict” causes intra-articular damage
• Mechanically-based treatment goal: Improvement in joint clearance

http://www.clinicalsportsmedicine.com/wp-content/uploads/2012/05/FAI.jpg
Treatment of Pincer Impingement

• Rim trim, with labral repair
Treatment of Pincer Impingement

- Acetabular re-orientation

- **Anteverting PAO**: described for treating pincer FAI due to acetabular retroversion

- **Reverse PAO** differs from anteverting PAO by uncovering lateral and anterior femoral head, ± anteverting acetabulum
Treatment of CAM Impingement

• Femoral head/neck osteochondroplasty
Hip Arthroscopy to Treat FAI
Treatment of FAI: Arthroscopic Approach

Before:

After:

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FAI: Case Example

18yo M collegiate baseball pitcher with 3-4 year history of worsening right hip pain, worse in positions of flexion or rotation of the hip.
FAI: Case Example

• 18yo M collegiate baseball pitcher with 3-4 year history of worsening right hip pain, worse in positions of flexion or rotation of the hip
FAI: Case Example
Pincer FAI: Acetabular Retroversion

• Retroverted acetabula:
  • Smaller lunate cartilage
  • Larger fossa

Steppacher et al, Osteoarthritis and Cartilage, 2014
Acetabular Retroversion: Reorientation vs Rim-trim?

Periacetabular Osteotomy Provides Higher Survivorship Than Rim Trimming for Acetabular Retroversion

Corinne A. Zurmühle MD, Helen Anwander MD, Christoph E. Albers MD, Markus S. Hanke MD, Simon D. Steppacher MD, Klaus A. Siebenrock MD, Moritz Tannast MD

CORR 2017
Acetabular Retroversion: Reorientation vs Rim-trim?

Zurmuhle, CORR 2017

- 67 anteverting PAOs
- 57 SD, rim-trim
- Endpoints: THA, progression of OA, d’Aubigne-Postel <15
- Kaplan-Meier curves
- Survivorship @10 yrs:
  - 79% Anteverting PAO
  - 23% Rim-Trim
- All rim-trims including labral repair
- None of anteverting PAOs had labral surgery, but still had better results
- Architectural correction more important than labral surgery

Graph showing Kaplan-Meier curves for 5 and 10 years survival rates:
- Anteverting PAO:
  - 5 Years: 85.6% (76-94)
  - 10 Years: 79.1% (68-90)
- Rim Trimming:
  - 5 Years: 85.9% (76-96)
  - 10 Years: 23.0% (6-40)

Followup (years)

Survival Rate (%)

p < 0.001
Pincer FAI: Deep Acetabula

Is Increased Acetabular Cartilage or Fossa Size Associated With Pincer Femoroacetabular Impingement?

Stephanie Y. Pun MD, Andreas Hingsammer MD, Michael B. Millis MD, Young-Jo Kim MD, PhD

CORR 2017

<table>
<thead>
<tr>
<th>Dysplastic</th>
<th>Control</th>
<th>Deep</th>
</tr>
</thead>
</table>
| Globally smaller cartilage and cotyloid fossa sizes | • Larger anterior and posterior cartilage sizes  
• Normal fossa size | • Smaller superior cartilage size  
• Larger fossa width and height |

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Pincer FAI: Deep Acetabula

• Finite element models

• Protrusio acetabula have 54% higher medial joint contact pressures than normal

• **Rim-trimming: 28% increase** in peak joint contact pressures

• **Reverse PAO: 25% reduction** in peak joint contact pressures

(Liechti et al, JOR 2015)
Deep Acetabula: Reorientation vs Rim-trim?

Hips With Protrusio Acetabuli Are at Increased Risk for Failure After Femoroacetabular Impingement Surgery: A 10-year Followup

Markus S. Hanke MD, Simon D. Steppacher MD, Corinne A. Zurmühle MD, Klaus A. Siebenrock MD, Moritz Tannast MD
CORR 2016

• Case-control study of protrusio vs FAI hips
• Endpoints: THA, progression of OA, d’Aubigne-Postel <15
• Survivorship @ 10yr followup:
  • 51% protrusio
  • 83% FAI
Reverse PAO for Global Overcoverage

- 31 hips
  - 18 left, 13 right
- 26 patients
  - 18 female, 8 male
- Average age at time of surgery
  = 19.4 years
- Average length of follow-up
  = 30.4 months
Results

- **Decreased** post-operative femoral head coverage
  - LCEA 41.7° → 35.3°
  - TA -7.4° → -3.7°
  - ACEA 44.0° → 35.3°
Results

- **Improved** post-operative pain and stiffness

- Lower WOMAC pain score: 8.8 → 4.2
- Lower WOMAC stiffness score: 3.5 → 1.9

WOMAC Scores

- Pain: PREOP = 9, POSTOP = 4
- Stiffness: PREOP = 3, POSTOP = 2

*p<0.001
Results

• **Improved** post-operative function and quality of life

• Better WOMAC function score:
  \[24.8 \rightarrow 10.0, \ p<0.001\]

• Higher MHHS:
  \[60.8 \rightarrow 83.2, \ p<0.0001\]
FAI Summary

- Arthroscopy can treat majority of FAI
- CAM → scope
- Pincer deformities more challenging
- Acetabular Retroversion
  - Mild, cranial retroversion → rim-trim ok
  - Global retroversion → anteverting PAO
- Global Overcoverage
  - No clearly great answer yet
  - Reverse PAO may be better than rim-trim
Conclusions & Future Directions

• Understanding the mechanical behavior of the hip is most important
  • Dynamic assessment of mechanical disease
  • Consideration of acetabular and femoral version affecting hip stability and impingement

• Structural correction of hip deformity is key

• Arthroscopy has a limited role in hip dysplasia

• Consider acetabular reorientation instead of rim-trimming in acetabular retroversion and protrusio

• More clinical studies needed
Thank You

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