E-Poster #32

Evaluating Stability in Borderline Hip Dysplasia using The Femoro-Epiphysyal Acetabular Roof Index

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Disclosure Information

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Speaker’s Bureau
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Consultant
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Major Shareholder
  • None

Other
  • None
Dysplastic acetabulum associated with varying degrees of stability

UNSTABLE
Borderline/Transitional
STABLE
Introduction

Classifying hips with mild structural deformity along the spectrum of stability is currently subjective and inexact.

Stable mechanics = FAI
Unstable mechanics = Dysplasia
FEAR Index

Originally proposed by Martin Beck, MD

Derived from Pauwels’ and Maquet’s theory that the upper femoral epiphyseal plate will become oriented perpendicular to the joint reactive forces in accordance with the Heuter-Volkman principle

Potentially serving as a developmental marker of hip stability

High intra/inter-rater reliability

Wyatt et al. CORR, 2017, 475:861-9
Measuring the FEAR

Positive FEAR Index (Away from Pelvis)
Unstable Hip

Negative FEAR Index (Towards Pelvis)
Stable Hip
Purpose

Extend analysis over a wider age spectrum, repeat analysis in a North American cohort, and to include a larger experimental group with controls
Questions

1. What are the characteristic of the FEAR index in children?

2. How does the FEAR index change with skeletal maturation?

3. How does the FEAR index correlate with clinical diagnosis and surgical treatment in a large cohort of symptomatic hips and asymptomatic controls?

4. How does the FEAR index correlate with clinical diagnosis within the borderline/transitional hip (LCEA 20-25°) group?

5. How does the FEAR index correlate with the diagnosis of dysplasia and FAI in a subgroup between -4° and 0°
Methods

Retrospective Review: 2007-2017

Experimental Group (n=368 hips, 205 patients): DDH (n=262) or FAI (n=106)

Exclusion:
- Femoral head deformities that prevented measurement of the LCEA
- Tonnis osteoarthritis grade >1
- Prior hip surgery
- Prior femoral osteotomy

Treatment Received:
- PAO for DDH
- Open or arthroscopic tx for FAI
- Conservative non-operative tx
Methods

Control Group (n=125):
Age matched ER trauma patients with standardized AP pelvis (matched 3:1)

Exclusion:
Pelvic trauma
Previous hip/pelvis surgery
Methods

Radiographic Measures
- LCEA
- FEAR Index
- Cross-over Sign
- ACEA
- Tönnis angle
- Shenton’s line
Methods: Statistical Analysis

- Two-way ANOVA to examine change in FEAR Index based on both age and diagnosis
- One-way ANOVA with post-hoc Bonferroni correction for comparison of FEAR Index between groups (DDH, FAI, Control)
- Receiver operator characteristics (ROC) curve was to determine an optimal cut-off value for FEAR Index
1. What are the characteristic of the FEAR index in children?

2. How does the FEAR index change with skeletal maturation?

**Subgroup analysis by skeletal maturity:**
- **Childhood:** <10 years old
- **Adolescent:** 10-15 years old
- **Maturity:** >15 years old
- No FAI < 10 years old
- FEAR decreases with increasing age for DDH and controls (P<0.001)
- FEAR is morphology specific in children & adolescents (P<0.001)
- Relationship between FEAR and diagnosis remained consistent within each age group (P=0.149)
3. How does the FEAR index correlate with clinical diagnosis and surgical treatment in a large cohort of symptomatic hips and asymptomatic controls?
Question 3

FEAR Index and Diagnosis for Entire Cohort

<table>
<thead>
<tr>
<th>Number</th>
<th>FEAR Index (Mean ± STD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dysplasia</td>
<td>262</td>
</tr>
<tr>
<td>FAI</td>
<td>106</td>
</tr>
<tr>
<td>Control</td>
<td>125</td>
</tr>
</tbody>
</table>
FEAR Index for Operative vs Nonoperative Hips

DDH Hips

P < 0.001

FAI Hips

P = 0.043
AUC = 0.909

ROC Curve for all hips

- Curve used to detect optimum cut-off value for diagnostic accuracy: -4°
- Data from curve showed greater than 0° is a sharp decrease in false positive rate
  - i.e. high positive predictability for dysplasia
Predictive Value of FEAR Index in Entire Cohort

Using -4° as Cutoff for Stable/FAI/Control

82% of all hips with FEAR < -4° are STABLE w/ clinical dx of FAI/control

<table>
<thead>
<tr>
<th></th>
<th>FEAR Index &gt; -4°</th>
<th>FEAR Index &lt; -4°</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unstable (n=262)</td>
<td>86% (218)</td>
<td>18% (44)</td>
</tr>
<tr>
<td>Stable/Control (n=231)</td>
<td>14% (35)</td>
<td>82% (196)</td>
</tr>
</tbody>
</table>
### Predictive Value of FEAR Index in Entire Cohort

Using $0^\circ$ as Cutoff for Dysplasia

92% of all hips with FEAR $>0^\circ$ are UNSTABLE with a clinical dx of DDH

<table>
<thead>
<tr>
<th></th>
<th>FEAR Index $&gt;0^\circ$</th>
<th>FEAR Index $&lt;0^\circ$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unstable/Dysplasia</td>
<td>92% (183)</td>
<td>27% (79)</td>
</tr>
<tr>
<td>(n=262)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stable/FAI/Control</td>
<td>8% (15)</td>
<td>73% (216)</td>
</tr>
<tr>
<td>(n=231)</td>
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</tbody>
</table>

**FEAR Index by Diagnosis**

Dysplasia | FAI | Control
How does the FEAR index correlate with clinical diagnosis within the borderline/transitional hip (LCEA 20-25°) group?
Question 4

FEAR Index and Diagnosis for Borderline Hip (LCEA 20°-25°)

<table>
<thead>
<tr>
<th>Number</th>
<th>FEAR Index (Mean ± STD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dysplasia</td>
<td>92</td>
</tr>
<tr>
<td>FAI</td>
<td>44</td>
</tr>
<tr>
<td>Control</td>
<td>33</td>
</tr>
</tbody>
</table>
Predictive Value of FEAR in Borderline Hips (LCEA 20° - 25°)

### Cutoff of 0°

96% of all borderline hips with FEAR > 0° are UNSTABLE (DDH)

<table>
<thead>
<tr>
<th></th>
<th>FEAR Index &gt; 0°</th>
<th>FEAR Index &lt; 0°</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dysplasia (n=92)</td>
<td>96% (48)</td>
<td>37% (44)</td>
</tr>
<tr>
<td>FAI/Control (n=77)</td>
<td>4% (2)</td>
<td>63% (75)</td>
</tr>
</tbody>
</table>

### Cutoff of -4°

76% of all borderline hips with FEAR < -4° are STABLE (FAI/control)

<table>
<thead>
<tr>
<th></th>
<th>FEAR Index &gt; -4°</th>
<th>FEAR Index &lt; -4°</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dysplasia (n=92)</td>
<td>83% (72)</td>
<td>24% (20)</td>
</tr>
<tr>
<td>FAI/Control (n=77)</td>
<td>17% (15)</td>
<td>76% (62)</td>
</tr>
</tbody>
</table>
5. How does the FEAR Index correlate with dysplasia and impingement within the “gray zone” (ie. -4° - 0°)?
55/368 hips were the gray zone
  - 35 dysplasia
  - 15 FAI
  - 5 control

22% of borderline patients are in the gray zone compared to only 6% of non-borderline patients (P<0.001)

67% of gray zone hips are also borderline (n=37) (P<0.001)
Is acetabular retroversion complicating FEAR index?

- If no retroversion, 96% of hips are DDH/control

<table>
<thead>
<tr>
<th></th>
<th>Retroversion</th>
<th>No Retroversion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dysplasia (n=35)</td>
<td>46% (12)</td>
<td>79% (23)</td>
</tr>
<tr>
<td>FAI (n=15)</td>
<td>54% (14)</td>
<td>4% (1)</td>
</tr>
<tr>
<td>Control (n=5)</td>
<td>0% (0)</td>
<td>17% (5)</td>
</tr>
</tbody>
</table>
FEAR Cut Offs in the Literature:

- $< 5^\circ$, correctly identified 79% of stable hips, Wyatt et al (n=59)
- $> -5^\circ$, correctly identified 69.4% of unstable hips, Truntzer et al (n=167 hips)
- $> 0^\circ$, correctly identified 92% of unstable (DDH) hips, (Current Study)
- $< -4^\circ$, correctly identified 82% of stable (FAI/control) hips, (Current Study)

High intra/inter-rater reliability:

- ICC 0.778, Wyatt et al
- ICC 0.99, Truntzer et al
- ICC 0.92, (Current Study)
Limitations

1. Single surgeon study
2. Diagnoses derived from combination of physical exam, plain radiographs, and advanced three-dimensional imaging, personal criteria (ROM, Tonnis, femoral morphology, age)
3. Ignores other determinants of (e.g. laxity or femoral version)
Conclusion

1. The FEAR index has a developmental basis correlating with diagnosis of DDH and FAI
2. A positive (> 0°) FEAR index correlates with unstable/DDH in 92% of all hips
3. A positive (> 0°) FEAR index correlates with unstable/DDH in 96% of all borderline/transitional hips (n=169)
4. The predictive value of FEAR declines substantially between -4 and 0, especially in presence of cross-over sign.
Clinical Utility

1. FEAR useful as a general appraisal method for less sophisticated clinicians

2. FEAR between $-4^\circ$ – $0^\circ$ useful to identify difficult-to-categorize hips (e.g. borderline retroverted hips) that will require more sophisticated analysis and perhaps a separate scoring system
Thank You