Hip Biomechanics and Osteotomies

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Organization

- Introduction
- Hip Biomechanics
- Principles of Osteotomy
- Femoral Osteotomies
- Pelvic Osteotomies
- Summary
Introduction

• Osteoarthritis is very prevalent
• Primary OA most common
• Secondary OA not insignificant
• Three main pediatric hip pathologies
  • Hip Dysplasia
  • Legg-Calve-Perthes Disease
  • Slipped Capital Femoral Epiphysis
Hip Mechanics

- Hip designed to support BW permit mobility
- Max ROM 140 flex/ext, 75 add/abd
- Functional ROM 50-60 flex/ext
- 1.8-4.3 x BW through hip
- Highest ascending stairs
Hip Biomechanics

• Forces acting across a hip joint can be measured either
  • Directly with implanted strain-gauged endoprosthesis
  • Mathematical model calculations – 2D static analysis
2D Static Analysis

- One legged stance 5/6 BW on femoral head
- Ratio of lever arms to BW 3:1
Biomechanics of Cane

- Cane in contralateral hand decreases JRF
- Long moment arm makes so effective
- 15% BW to cane reduces joint contact forces by 50%
Biomechanics

• Dynamic analysis much more complex

• Forces across hip joint combination of:
  • Body weight
  • Ground reaction forces
  • Abductor muscle forces
Biomechanics

- Improving abductor function will decrease joint reactive forces.
Secondary Osteoarthritis

- Prevalence of OA by age 50
  - DDH 40-50%
  - LCP 50%
  - SCFE 20%

- Despite many recent advances arthroplasty has many limitations in younger patients
Avoiding Revision Arthroplasty

FIG. 2. AP radiographs of a relatively young patient with bilateral cemented total hip arthroplasties. Both hips have been in place approximately 20 years. Massive acetabular bone loss on the left hip will make reconstruction a challenging endeavor in this relatively young, healthy patient.
Why does Osteotomy work?

- Osteotomies improve hip function
  - Increasing contact area / congruency
  - Improve coverage of head
  - Moving normal articular cartilage into weight bearing zone
  - Restore biomechanical advantage / Decreasing joint reactive forces
  - ?? Stimulating cartilage repair
Principles of Osteotomy

• Ostoeotomy can be viewed as either
  • Reconstructive
  • Salvage
• Femoral osteotomy to correct proximal femoral abnormalities and vice versa
Pre-op Evaluation

- **Physical exam to ensure ROM**
- **Plain films**
  - Standing AP
  - Frog leg lateral
  - False profile (anterior lip cover.)
  - Full abduction/adduction
- **CT scan +/- 3D reconstruction**
Contraindications to Osteotomy

- Neuropathic arthropathy
- Inflammatory arthropathy
- Active infections
- Severe osteopenia
- Advanced arthritis/ankylosis
- Advanced age
- Smoking, obesity
Varus Femoral Osteotomy

• **Intact lateral portion of femoral head is prerequisite**

• **Can be combined with either flexion or extension component**
Varus Osteotomy

- **Indications:** Hip joint instability because of femoral deformity which corrects with internal rotation & abduction view.
- Pelvic osteotomy should be performed in pts with CEA < 15 degrees.
- Useful in DDH, SCFE, LCP, AVN, and femoral neck non-union/malunion.
Disadvantages of varus femoral osteotomy

- Potential to shorten limb
- Weaken abductors
- Trendelenburg gait
- Potential difficulty with stem insertion in future arthroplasty
Valgus Femoral Osteotomy

- Coxa vara
- Performed if adduction film reveals concentric reduction
Valgus Femoral Osteotomy

- Moves non-inervated inferior cervical osteophytes into contact with floor of acetabulum
- Lateral traction on superior capsule may stimulate fibrocartilage transformation
Pelvic Osteotomies

• **Reconstructive**
  - Salter 18m – 6y
  - Pemberton 18m – 10y
  - Steel skeletal maturity
  - PAO (Ganz) skeletal maturity

• **Salvage**
  - Chiari skeletal maturity
Overview of Pelvic Osteotomies

Diagram of pelvic structures showing various osteotomies:
- Salter
- Pemberton
- Steel
- Sutherland
- Chiari
- Dial
# Pelvic Osteotomies

## Table 4-10.

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Osteotomy Description</th>
<th>Requirements</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salter</td>
<td>Innominate (open wedge)</td>
<td>• Congruous acetabular dysplasia</td>
<td>• Does not always provide good lateral coverage</td>
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<tr>
<td></td>
<td></td>
<td>• CE angle &gt;12-15 degrees</td>
<td>• Used primarily in early youth</td>
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<tr>
<td></td>
<td></td>
<td>• Anterior and lateral redirection of acetabulum</td>
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<tr>
<td>Double or triple innominate</td>
<td>Innominate and pubis or innominate and both rami</td>
<td>• CE angle 0-15 degrees</td>
<td>• For more advanced dysplasia</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Congruous acetabular dysplasia</td>
<td>• Preserves triradiate cartilage</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Used primarily in youth</td>
</tr>
<tr>
<td>Spherical acetabular osteotomy</td>
<td>Acetabular Subchondral</td>
<td>• Almost any CE angle</td>
<td>• Medialization of acetabular segment complex and difficult</td>
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<tr>
<td></td>
<td></td>
<td>• Must have closed triradiate cartilage (compromises vascular supply to area)</td>
<td>• Capsulotomy contraindicated</td>
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<tr>
<td></td>
<td></td>
<td>• Congruous acetabular dysplasia</td>
<td>• Complications of osteonecrosis and intra-articular penetration frequent</td>
</tr>
<tr>
<td>Periacetabular osteotomy (Ganz et al.)</td>
<td>Periacetabular</td>
<td>• Almost any CE angle</td>
<td>• Capsulotomy is safe (allows look for labral tears)</td>
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<tr>
<td></td>
<td></td>
<td>• Congruous acetabular dysplasia</td>
<td>• Medialization of acetabulum is easy</td>
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<td></td>
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<td></td>
<td>• Minimal fixation required; only 2-4 screws</td>
</tr>
<tr>
<td>Chiari's osteotomy</td>
<td>Curved innominate slides iliac shelf over uncovered femoral head and capsule; interposed capsule undergoes metaplasia into cartilage material</td>
<td>• Unstable aspherical joint</td>
<td>• Preferred osteotomy in adult</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Salvage osteotomy only</td>
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<td></td>
<td>• Leaves anterior acetabulum uncovered</td>
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<td></td>
<td>• Abductor lurch common after Chiari's unless trochanteric advancement is performed</td>
</tr>
</tbody>
</table>
Salter Osteotomy

- Single Innominate osteotomy
- Acetabulum together with ilium and pubis rotated
- Held by wedge of bone
- Illiopsoas & adductor tenotomies common
- 18 mon to 6 years
Pemberton Osteotomy

• Pericapsular osteotomy for residual dysplasia
• Hinges through the triradiate cartilage – must be open!!
• Changes the volume & orientation of acetabulum
• Although good results up to 10 most recommend 6 to 8 years
Steel Triple Innominate Osteotomy

- **Indication**: DDH in older child
- **Need good ROM**
- **Secure with bone graft & AO screw fixation**
Steel Osteotomy

- Contraindications
  - Limited ROM
  - Incongruous reduction
  - Significant joint space narrowing / degenerative arthritis
- Two incision approach
Periacetabular Osteotomy

- Devised by Ganz
- Indication - DDH in adolescents & adults
- Achieves correction of containment & congruency
Periacetabular Osteotomy - Advantages

- Permits extensive reorientation
- Preserves blood supply
- Posterior column remains intact – true pelvis unchanged
- Single incision
- Preferred reconstructive osteotomy for acetabular dysplasia
Periacetabular & Femoral Osteotomy

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Chiari Osteotomy
Chiari Osteotomy

- Devised by Chiari 1950’s
- Salvage procedure
- Relief of pain in incongruous hip
- Increases coverage by medializing hip centre
- Fibrocartilage transformation of superior capsule
Chiari Osteotomy Results

- Chiari reported 200 procedures
  - 2/3 good to excellent outcome
  - 1/3 improved
- Similar results by others
- While pain relief is predictable, trendelenburg gait remains
- Trochanteric advancement may alleviate trendelenburg gait