Hip Instability:
Traumatic Instability, FAI-Induced Instability, Atraumatic Microinstability & Iatrogenic Instability

Shane J. Nho, MD, MS
Hip Preservation Center, Division of Sports Medicine, Department of Orthopedic Surgery, Rush University Medical Center

Disclosures
Consultant: Stryker, Ossur
Research Support: Arthroscopy Association of North America, Stryker, Allosource

Not all hip instability is the same…
Laxity

Asymptomatic passive translation of the femoral head relative to the acetabulum

Beighton criteria:
- Placing flat hands on the floor with all eight legs
- Left knee bending backward
- Right knee bending backward
- Left elbow bending backward
- Right elbow bending backward
- Left thumb touching the forearm
- Right thumb touching the forearm
- Left little finger bending backward past 90 degrees
- Right little finger bending backward past 90 degrees

Instability

Symptomatic pathologic translation of the femoral head during active hip activity

Spectrum of Hip Instability
**Hip Biomechanics**

**Static Factors**
- Stabilize femoral head in acetabulum

**Dynamic Factors**

---

**Hip Joint Stability**

**Hip joint stability**

**Static stabilizers**
- Osseous morphology & version
- Labrum
- Capsuloligamentous
- Suction seal: negative intraarticular pressure / adhesion-cohesion

**Dynamic stabilizers**
- Gluteus medius and minimus
- Short external rotators
- Iliopsoas
- Neuromuscular control
- Proprioception

---

**Osseous Morphology**

**Radiographic Appearance of Hips**
- Impingement (Deep) ↔ Normal ↔ Dysplasia (Shallow)
Is there a role for hip arthroscopy in dysplasia?

- 36 Hips for dysplasia (DDH in 30; Retroversion in 6) and FAI underwent HA (labral debridement and osteoplasty
  - Improvement at 6 wks then deteriorated over time
  - 13 Femoral head migration
  - 14 Accelerated OA

- 2 cases of rapid acceleration of hip OA

Mei-Dan et al. Catastrophic Failure in Hip Arthroscopy Due to Iatrogenic Instability: Can Partial Division of Lig Torae and Iliofemoral Ligament Cause Subluxation? Arthroscopy 2012.
Dysplastic Variants

• Borderline dysplasia
  • Domb et al. AJSM 2013.
    • 26 patients with CEA 22.2° (range, 18-25°) underwent HA with labral repair and capsular plication
    • 77% (17/22) G/E outcome
    • 14% (3/22) Tonnis 0 → 1
    • 9% (2/22) Revision

Domb et al. AJSM 2013.

Dysplasia Variants

• Excessive femoral anteversion/Femoral valgus
  • Femoral anteversion > 25°
    • Iliopsoas lengthening with femoral anteversion > 25° have inferior clinical outcomes (Fabricant et al. Arthroscopy 2012.)
    • Recent studies do not show a difference in outcome and femoral version (Ferro et al. Arthroscopy 2015)


Acetabular Labrum

- Deepens the socket allowing for greater coverage of the femoral head
- Maintain stability
- Decrease contact pressure
- Provides a fluid seal for the hip joint
- **Most common area of injury is at the capsulolabral junction

Labral Function

Labrum maintains intra-articular fluid pressurization
- Decreases with labral tear / resection
  - Through-type labral repair > looped-type labral repair
  - Labral reconstruction normalized IAP
Labrum stabilizes hip by maintaining suction seal at small displacement (1-2mm) but capsule has a greater role at larger displacement
  - May explain microinstability in the setting of labral injury.

Noppe et al. KSSTA 2014.

Labrum Contact Mechanics

Findings: Compared to normal hips, the labrum in dysplastic hips supported a larger percentage of total load transferred to the hip.

Dysplastic Normal


Labral Reconstruction With Iliotibial Band Autografts and Semitendinosus Allografts Improves Hip Joint Contact Area and Contact Pressure

An In Vitro Analysis

Lee et al. AJSM 2014.
After labral resection, there was a statistically significant decrease in contact area at both 20° extension (73.2%±5.38, p<0.0005) and 60° flexion (78.5%±6.93, p=0.0026).

Following reconstruction of the labrum with ITB autograft, the contact area increased significantly from the resected state at both 20° extension (87.2%±12.3, p<0.0269) and 60° flexion. 90.5%±8.81, p<0.0027).

Contact pressures significantly increased following labral resection at both 20° extension (106.7%±4.15, p<0.0181) and 60° flexion (103.9%±1.15, p<0.0039).

Contact pressures significantly decreased as compared to the resected state after ITB reconstruction at both 20° extension (98.5%±5.71, p<0.0109) and 60° flexion (96.6%±1.13, p<0.0010).

Role of the Acetabular Labrum and the Iliofemoral Ligament in Hip Stability
An In Vitro Biplane Fluoroscopy Study
Casey A. Myers,* MSc, Bradley C. Register,§ MD, Pasit Lertwanich,∥ MD, Leandro Ejnisman,* MD, W. Wes Pennington,* MD, J. Erik Giphart,* PhD, Robert F. LaPrade,* MD, PhD, and Marc J. Philippon,*|| MD
Investigation performed at the Biomechanics Research Department of the Steadman Philippon Research Institute, Vail, Colorado
Quantification and correlation of hip capsular volume to demographic and radiographic predictors

Jonathan M. Frank · Simon Lee · Frank M. McCormick · Mark Jordan · Bryce Austell · William Slikker · Michael J. Salata · Shane J. Nho

Frank et al. KSSTA 2014.

19/77 patients had MRA for suspected labral injury with FAI
- Males had larger total capsular volume, femoral head volume, and true capsular volume compared to females
- No difference TCV / FHV

*Study does not account for the tissue histology and connective tissue content
  - Increased elastin (Rodeo AJSM 1996)
  - Increased cysteine - AA found in type III collagen and fibrillin (Hirakawa et al. 1991)

Anterior Hip Capsule and Ligamentous Support

Anterior Static Stabilizers: restrains extension & external rotation
- Iliofemoral ligament (Y Ligament of Bigelow): strongest hip ligaments
  - Originates from AIS and inserts on the intertrochanteric line of femur.
  - Terminal fibers form zona orbicularis
  - “Screw home” mechanism with hip extension / ER
- Pubofemoral ligament
  - Originates from the pubic ram and inserts on the intertrochanteric crest

Rotational Properties of Capsular Ligaments

The Function of the Hip Capsular Ligament: A Quantitative Report

Lateral Iliofemoral lig: ER / flexion; ER / IR in extension
Pubofemoral lig: ER in extension
Ischiofemoral lig: IR in flex & ext
Capsular Thickness

Capsule is thickest at 2 o'clock position at IFL with a max thickness of 8.3mm at 10mm and 15mm.
Capsule is thinner between 4.1mm at 4 and 11 o'clock.
Recommend capsulotomy at 1-2 o'clock between 8-10mm from the labrum.

Posterior Hip Capsule and Ligamentous Support

Posterior Static Stabilizers: restrains internal rotation in flexion and extension
  - Ischiofemoral ligament: originates from the ischial rim and inserts on the posterosuperior base of the GT
    - Blends with zona orbicularis posteriorly
Zona Orbicularis
  - Encircles entire femoral neck
  - Functions as locking ring around the femoral neck and provides stability with distraction

Ligamentum Teres

Ligamentum Teres
  - Travels from the inferior aspect of the acetabulum at the transverse acetabular ligament to fovea of the femoral head (fossa capitis)
  - Tension with adduction and ER
  - May serve as a secondary stabilizing structure
  - Torn LT has been described as a source of hip pain (Byrd & Jones. Arthroscopy 2004).
    - Some have recommended debridement (Keen & O'Sullivan. KSSTA 2011)
    - Some have recommended LT reconstruction (Amaral et al. J Am Acad Orthop Surg 2011)
    - Others recommend surgical excision (Philippon et al. JBJS Br 2013).
Pre-Capsular Venting

Post-Capsular Venting

Negative Intra-Articular Pressure

Adhesion - Cohesion

Femoral Head  Acetabulum

Dynamic Stabilizers

Shoulder
- Rotator cuff
  - Stabilize humeral head, GH motion, dynamic joint compression
- Scapular rotators
- Long head of Biceps: humeral head depressor
- Neuromuscular Control & Proprioception

Hip
- Gluteus medius/minimus
- Short external rotators
- Iliopsoas
- Neuromuscular Control & Proprioception
Spectrum of Hip Instability

Traumatic Hip Instability

Traumatic Instability
High energy: motor vehicle accident

Lower energy: athletic competition with fall on flexed hip
  - Football, rugby, soccer, gymnastics, basketball, biking


Management of Acute Hip Dislocations

History and physical exam
  - Hip fixed in flexion, adduction, internal rotation
  - Neurovascular exam

Radiographs: AP & lateral views & Judet views

Acute management: closed reduction < 6 hrs
  - AVN 7-25%
  - CT scan after reduction
  - Operative
    - Acute arthroscopy for retained fragment
    - ORIF: Fracture - Dislocations
Traumatic Hip Instability

Traumatic hip subluxations
- MRI
Moorman et al. (JBJS 2003)
traumatic posterior hip subluxation
have triad of posterior acetabular lip
fracture, iliofemoral ligament
disruption, and hemarthrosis
- Fluoroscopic aspiration to
decrease intracapsular
pressure
- PWB for 6 wks
- Posterior hip precautions
- Repeat MRI to determine
presence of AVN

FAI Induced Hip Instability

Traumatic Hip Dislocations
(Philippon et al. Arthroscopy 2009)
- All 14 RTP in professional
athletes
- 9 of 14 with FAI
FAI – Induced Hip Instability
(Krych et al. CORR 2012)
- 20 of 22 patients RTP
- 18 of 22 with FAI
MOI
- No FAI: posterior directed
force with hip in flexion –
adduction (ie, dashboard)
- FAI: torsion and
hyperflexion
Krych et al. CORR 2012.

Atraumatic Hip Instability

The role of arthroscopic thermal
capsulorrhaphy in the hip.
Marc J. Philippon

Atraumatic hip instability
- Generalized ligament laxity, connective tissue disorders (Ehlers-
Danlos, Down syndrome, arthrochalasis, developmental
dysplasia of the hip)
- IFL deficiency and role in hip instability
9 High level athletes returned to their pre-injury level of function
Short-term results appear promising
Largely supplanted by suture capsular plication
Atraumatic Hip Instability

**Capsular laxity**
- Etiology: repetitive microtrauma, generalized lig laxity, connective tissue disorders, etc.
- Symptoms: groin pain and associated snapping iliopsoas tendon in setting of hypermobility
- MOI: increased translation may cause labral injury
- Surgery: controversial

**Imaging Studies**
- Radiographs / CT scan: Osseous anatomy to identify dysplasia or variants
- MRI: attenuation of lateral insertion of IFL with max ER (60°)

**Pathomechanics**
- Normal osseous morphology
- Trends towards increased abduction and ER (ie, turnout) and decreased IR
- Femoral head subluxation of 2.05mm – 5.14mm in dancers when in splits position (Duthon et al. Arthroscopy 2013)

**Femoral Retroversion**
- Charbonnier et al. AJSM 2011.

**Treatment:**
- Hip arthroscopy labral refixation, capsular plication ± FAI (Duthon et al. Arthroscopy 2013)
- Charbonnier et al. AJSM 2011.

Iatrogenic Hip Instability

6 reported cases on macroinstability after hip arthroscopy
- Benali & Kathagen, Arthroscopy 2009.
- Ranawat et al. JBJS 2009.
- Sansone et al. KSSTA 2013.

Sansone et al. KSSTA 2013.
Complications and Reoperations During and After Hip Arthroscopy: A Systematic Review of 92 Studies and More Than 6,000 Patients


Table 3. Complications After Hip Arthroscopy

<table>
<thead>
<tr>
<th>Parameter</th>
<th>n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nerve injury</td>
<td>87 (1.4%)</td>
</tr>
<tr>
<td>Temporary</td>
<td>86 (99%)</td>
</tr>
<tr>
<td>Pudendal</td>
<td>34 (40%)</td>
</tr>
<tr>
<td>Lateral femoral cutaneous nerve</td>
<td>18 (21%)</td>
</tr>
<tr>
<td>Sciatic</td>
<td>15 (17%)</td>
</tr>
<tr>
<td>Common peroneal</td>
<td>15 (17%)</td>
</tr>
<tr>
<td>Femoral</td>
<td>4 (4.7%)</td>
</tr>
<tr>
<td>Permanent</td>
<td>1 (1%)</td>
</tr>
<tr>
<td>Sciatic (partial)</td>
<td>1</td>
</tr>
</tbody>
</table>

Iatrogenic

Chondral injury 241
Labral injury 54
Perineal skin damage 10
Labia/vagina 6
Scrotum 4
Infection 8
Superficial (antibiotic treatment) 7
Deep (arthrotomy, drainage) 1
Deep vein thrombosis 7
Pulmonary embolus 1
Avascular necrosis 10
Heterotopic ossification 42
Reflux sympathetic dystrophy 3
Broken instrumentation 9
Femoral neck fracture 3
Hypothermia 7
Hip dislocation 4
Extra-articular fluid extravasation 22
Intra-abdominal 19
Intrathoracic 3
Vascular injury 2
Occlusion at ankle caused by traction boot 1
Inferior gluteal artery laceration/pseudoaneurysm 1
Death 2
Unrelated 1
Pulmonary embolus 1

Evidence of capsular defect following hip arthroscopy

Frank McCormick • William Slikker III • Joshua D. Harris • Anil K. Gupta • Geoffrey D. Abrams • Jonathan Frank • Bernard R. Bach Jr • Shane J. Nho

McCormick et al. KSSTA 2013.

Why do I close the capsule?

20 yr old woman
- Oct 2011: femoral osteochondroplasty
- Oct 2012: iliopsoas lengthening

She cannot participate in any recreational activities

Groin pain worse with sitting, shoes and socks, walking on her toes
Why?

Rationale for Capsular Closure

- Understand Anatomy: Structure and Function of the IFL
- Capsulotomy
  - Size & location of Interportal
  - T-Capsulotomy
- Rationale for capsular closure: anatomic repair of the IFL should restore the biomechanical characteristics of the IFL.
  1. Axial strain
  2. Translation
  3. Rotation

Axial Strain

Video courtesy of Stephen Aoki, MD
Axial Strain

Video courtesy of Stephen Aoki, MD

Clinical Signs of Iatrogenic Microinstability

History: Pain with ADL
- Pain worse than prior to index surgery

Physical Exam
- Instability Test
- Apprehension
- Hypermobility

Capsular Adhesions
Effect of Capsulotomy on Hip Stability—A Consideration During Hip Arthroscopy

Christopher O. Bayne, MD, Robert Stanley, BS, Peter Simon, MS, Alejandro Espinoza-Orias, PhD, Michael J. Salata, MD, Charles A. Bush-Joseph, MD, Nozomu Inoue, MD, PhD, and Shane J. Nho, MD, MS

Thirteen fresh-frozen cadaveric specimens
Six reflective infrared markers (Eagle 4, Motion Analysis, Santa Rosa, CA)
4 conditions: Intact-Neutral, Intact-Flexion, Capsulotomy-Neutral, Capsulotomy-Flexion
ER torque 0.588 Nm

Bayne et al. AJO 2014.

Hip Kinematics

Bayne et al. AJO 2014.

Biomechanical Evaluation of Capsulotomy and Capsular Repair in the Hip: Restoring Stability

- Prior cadaveric studies in our lab have demonstrated that an interportal capsulotomy increases hip rotation and translation compared to an intact hip
- Increasing the size of the interportal capsulotomy has a dose dependent effect on rotation

Wuerz et al. Arthroscopy 2015 (Submitted).
Aim: use a cadaveric model to determine hip rotational motion differences in 5 capsular conditions
- Intact
- Interportal capsulotomy
- T-capsulotomy
- Repaired T-capsulotomy
- Capsulectomy

Methods

Seven fresh-frozen cadaveric specimens – 5M, 2F, 62 years
Muscle and soft tissue removed – capsule left intact
CT scan for morphology/motion tracking
Six reflective infrared markers (Eagle 4, Motion Analysis, Santa Rosa, CA)

Capsular interventions were performed in a single specimen sequentially:
- Intact
- Interportal capsulotomy (4 cm)
- T-capsulotomy
- Repaired T-capsulotomy
- Capsulectomy

Is Capsular Closure Necessary?
The Use of Double-Loaded Suture Anchors for Labral Repair and Capsular Repair During Hip Arthroscopy


Arthroscopy Techniques 2012

Routine Complete Capsular Closure During Hip Arthroscopy

Arthroscopy Techniques 2013
Surgical Technique

Improved Outcomes After Hip Arthroscopic Surgery in Patients Undergoing T-Capsulotomy With Complete Repair Versus Partial Repair for Femoroacetabular Impingement

A Comparative Matched-Pair Analysis


Investigation performed at Rush University Medical Center, Chicago, Illinois, USA

<table>
<thead>
<tr>
<th></th>
<th>Partial Closure</th>
<th>Complete Closure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patients</td>
<td>32</td>
<td>32</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td>Female</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>Age</td>
<td>32.87±9.84</td>
<td>32.65±10.16</td>
</tr>
<tr>
<td>Side of Surgery</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Left</td>
<td>13</td>
<td>20</td>
</tr>
<tr>
<td>Right</td>
<td>19</td>
<td>12</td>
</tr>
<tr>
<td>Center Edge Angle</td>
<td>33.27±5.51</td>
<td>34.15±5.57</td>
</tr>
<tr>
<td>Alpha Angle</td>
<td>56.91±11.15</td>
<td>59.43±8.27</td>
</tr>
<tr>
<td>Follow-up (min-max)</td>
<td>20.63 (12.1-31.7)</td>
<td>15.08 (12.10-19.04)</td>
</tr>
</tbody>
</table>

Frank et al. AJSM 2014.

Surgical Approach

1. T-capsulotomy with closure of vertical limb only (Partial Closure)
2. T-capsulotomy with complete capsular closure (Complete Closure)
Partial Closure vs. Complete Closure HOS ADL

Partial Closure vs. Complete Closure HOS SS
Arthroscopic Capsular Closure

Principles for capsular closure:
- Routine interportal capsulotomy in line with the joint
- Central compartment procedures can be performed
- Peripheral compartment
  - T capsulotomy between medial and lateral IFL
  - Tensioning
  - Plication stitches
- Restore biomechanical properties of the hip capsule
  - Restrain distraction, extension, ER

Discussion

Hip joint is inherently stable but is dependent on static and dynamic stabilizers:
- Identify osseous morphology
- Capsuloligamentous support
- Labrum

There are several sub-types of hip instability:
- Traumatic hip instability
- FAI-Induced instability
- Atraumatic hip instability
- Iatrogenic hip instability

Conclusions

Capsular management is an important aspect of hip arthroscopy:
- Improper management can lead to micro- or macro-instability

Capsulotomy is required for visualization and proper treatment of FAI:
- Understand the structure and function of IFL: Axial, Rotational, Translation
- Clinical studies may suggest that complete capsular closure can lead to improved functional outcomes
Hip Functionality

Pre-Op Functionality

<table>
<thead>
<tr>
<th>Closure</th>
<th>Pre-Op Functionality</th>
<th>Post-Op Functionality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Partial</td>
<td>4.24</td>
<td>7.29</td>
</tr>
<tr>
<td>Complete</td>
<td>4.66</td>
<td>8.03</td>
</tr>
</tbody>
</table>

Post-Op Hip Functionality

<table>
<thead>
<tr>
<th>Closure</th>
<th>Post-Op Functionality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Partial</td>
<td>7.29</td>
</tr>
<tr>
<td>Complete</td>
<td>8.03</td>
</tr>
</tbody>
</table>
Herodicus Traveling Fellowship

Hip Kinematics

Neutral (Capsulotomy)  Flexion (Capsulotomy)
Translation > Rotation  Rotation > Translation