Anterior Instability with Bone Loss

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Disclosure Information
TRIA Orthopaedic & Sports Medicine Conference:
Tackling Football Injuries
John E. Kuhn, MD MS

Disclosure of Relevant Financial Relationships

I have no financial relationships to disclose.

Disclosure of Off-Label and/or investigative Uses

I will not discuss off label use and/or investigational use in my presentation.
Points

• The Debate About the Contact Athlete
• Is Bone Loss a Problem?
  – Glenoid Side
  – Humerus Side
  – Combined
• How do we Measure Bone Loss?
• How do we Approach Bone Loss?
The Contact Athlete

• Should the Contact Athlete with Instability have OPEN or ARTHROSCOPIC Surgery?
• DOGMA
• One Comparative Studies
• All Level IV Evidence
Should the contact athlete be treated differently?

<table>
<thead>
<tr>
<th>Author</th>
<th>EBM</th>
<th>Treatment</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ide et al.</td>
<td>Level IV</td>
<td>21 patients arthroscopic repair with suture anchors</td>
<td>9.5% recurrence rate</td>
</tr>
<tr>
<td>Mazzocca et al.</td>
<td>Level IV</td>
<td>18 patients arthroscopic labral repair with suture anchors + capsulorrhaphy</td>
<td>11% recurrent dislocations</td>
</tr>
<tr>
<td>Bacilla et al.</td>
<td>Level IV</td>
<td>40 patients arthroscopic Bankart repair with suture anchors</td>
<td>7.5% recurrence rate</td>
</tr>
<tr>
<td>Uhorchak et al.</td>
<td>Level IV</td>
<td>66 patients open Bankart repair + capsulorrhaphy</td>
<td>23% recurrent subluxations</td>
</tr>
<tr>
<td>Pagnani &amp; Dome</td>
<td>Level IV</td>
<td>58 patients open repair with suture anchors +/- capsular shift</td>
<td>3% recurrent subluxations</td>
</tr>
</tbody>
</table>

Comparing Open Versus Arthroscopic Treatment in the Collision Athlete

- 48 shoulders collision athletes, mean FU 72 months
- 16 arthroscopic, 32 open
- No significant difference: VAS, Rowe, Constant
- Postoperative subluxation or dislocation: 25% in arthroscopic group versus 12.5% in open group (p = 0.041)

Risk Factors for Failure

• 194 consecutive arthroscopic Bankart repairs; 101 contact athletes
• Recurrence of Instability in Contact Athletes:
  – Without significant bony defects = 6.5%
  – With significant bony defects = 89%

Burkhart SS, De Beer JF. Arthroscopy. 2000 Oct
Are we Asking the Right Question?

• Should we ask:
  – Contact Athlete: Arthroscopic or Open Approach?
    OR
  – Contact Athlete With or Without bone loss?
RE-Frame the Debate:

• Contact Athletes may do well with Arthroscopic Treatment
• The Anatomy Drives the Approach!
  – Contact athletes are MORE LIKELY going to have Bone Loss
  – Those that DO have Bone Loss should have open surgery
  – Those that DO NOT have Bone Loss can be managed Arthroscopically
Is Bone Loss A Problem?

• Yes-Failure Rates of Instability Surgery are Much Higher with Bone Loss
• Glenoid Bone Loss
• Humeral Bone Loss
Glenoid Bone Loss
Reasons for Failure of Instability Surgery

- **Anterior Glenoid Bone Loss (55%)**
- Loose Capsule (22%)
- HAGL (5%)

Tauber M. JSES 2004;13:279-85;
How Much Bone Loss is Important?

![Table of Glenoid Loss Studies](image)

**GLENOID LOSS > 20%**

Bushnell Arthroscopy 2008;24(9):1061-73
Maybe <20%?

• Retrospective Cohort Study
• 72 Military Patients, 73 Shoulders
• Bone Loss in Quartiles
  – 2.8% (0-7.1%) N=18
  – 10.4% (7.3-13.5%) N=19
  – 16.1% (13.5%-19.8%) N=18
  – 24.5% (20.0-35.5%) N=18

Maybe <20%?

- All had arthroscopic repair
- Overall Failure Rate 12.3%
- Results:
  - Quartiles 1-3 significantly less recurrence (7.3%) than Quartile 4 (27.8) (Fits the 20% rule)...BUT
  - Each quartile’s increasing bone loss predicted a worse WOSI score
  - Threshold for significant decrease in WOSI was 13.5%!

How do we Measure Percent Bone Loss?

Bakshi NK et al Comparison of 3-diemnsional computed tomography-based measurement of glenoid bone loss with arthroscopic defect size estimation in patients with anterior shoulder instability. Arthroscopy 2015 in press
How do we Measure Percent Bone Loss?

Diameter = \( \frac{(B-A)}{2 \times B} \)

How do we Measure Percent Bone Loss?

RATIO METHOD:

\[
\frac{1}{\pi} \left( \cos^{-1} \left( \frac{d}{R} \right) - \frac{d}{R} \sqrt{1 - \left( \frac{d}{R} \right)^2} \right)
\]

How Do We Measure Glenoid Bone Loss?

<table>
<thead>
<tr>
<th>Bone</th>
<th>Technique</th>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glenoid</td>
<td>Arthroscopic</td>
<td>Bare spot</td>
<td>Using an arthroscopic probe, the distance in millimeters between the bare spot and the anterior glenoid rim is measured (A), as is the distance between the bare spot and the posterior glenoid rim (B). Bone loss = ((B - A)/B \times 100%).</td>
</tr>
<tr>
<td>Glenoid</td>
<td>CT (on face view of the glenoid on 3D surface rendering with humeral head subtraction or 2D oblique sagittal reconstruction)</td>
<td>Best-fit circle</td>
<td>A perfect circle is fit to the inferior two thirds of the glenoid. The surface area of the anterior rim defect is measured digitally. The defect areas divided by the total area of the best-fit circle to obtain the percentage of anterior bone loss.</td>
</tr>
<tr>
<td>Glenoid</td>
<td>CT (on face view of the glenoid on 3D surface rendering)</td>
<td>Glenoid index</td>
<td>Ratio of the maximum diameter of the lower two thirds of the injured glenoid fossa, compared with the maximum diameter of the contralateral uninjured glenoid fossa. A glenoid index of &lt;0.75 indicates that the patient will benefit from an open Latarjet procedure.</td>
</tr>
<tr>
<td>Glenoid</td>
<td>CT (on face view of the glenoid on 2D oblique sagittal reconstruction)</td>
<td>Pico method</td>
<td>A best-fit circle is drawn on the injured side. An identical circle is drawn on the uninjured glenoid, and the missing part of the circle is measured. The defect is quantified as a percentage of the total area of the uninjured circle.</td>
</tr>
<tr>
<td>Glenoid</td>
<td>CT</td>
<td>Glenoid rim distances</td>
<td>Distances are measured in millimeters from the bare spot to both the anterior glenoid rim (distance A) and the posterior rim (distance B). Bone loss = ((B - A)/B \times 100%).</td>
</tr>
<tr>
<td>Glenoid</td>
<td>CT (on face view of the glenoid on 3D surface rendering with humeral head subtraction or 2D oblique sagittal reconstruction)</td>
<td>Ratio method</td>
<td>Mathematical calculation. Percentage of the missing area is expressed as a function of the ratio between the distance from the center of the best-fit circle to the anterior glenoid rim and the radius of the circle.</td>
</tr>
</tbody>
</table>
# How Do We Measure Glenoid Bone Loss?

<table>
<thead>
<tr>
<th>Quantification Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Surface area method</strong>&lt;sup&gt;22&lt;/sup&gt;</td>
<td>Three-dimensional computed tomography image of glenoid with humeral head subtraction is obtained</td>
</tr>
<tr>
<td></td>
<td>Best-fit circle is drawn on inferior 2/3 of pear-shaped glenoid</td>
</tr>
<tr>
<td></td>
<td>Osseous deficiency is measured directly on circle with use of digital means</td>
</tr>
<tr>
<td><strong>Superimposed circle method</strong>&lt;sup&gt;8&lt;/sup&gt;</td>
<td>Best-fit circle centered at bare-spot approximation is drawn on injured glenoid and contralateral, uninjured glenoid</td>
</tr>
<tr>
<td></td>
<td>Glenoid circle on normal shoulder is superimposed on injured-shoulder circle</td>
</tr>
<tr>
<td></td>
<td>Preinjury size and amount of bone loss are calculated</td>
</tr>
<tr>
<td><strong>Pico method</strong>&lt;sup&gt;47&lt;/sup&gt;</td>
<td>Best-fit circle is drawn on inferior portion of contralateral, uninjured glenoid with use of MPR (multiplanar reconstruction) software, and its surface area (A) is digitally calculated</td>
</tr>
<tr>
<td></td>
<td>Circle is superimposed onto injured glenoid, and surface area of defect (D) is calculated</td>
</tr>
<tr>
<td></td>
<td>Percent bone loss = D/A × 100%</td>
</tr>
<tr>
<td><strong>AP distance from bare area method</strong>&lt;sup&gt;26&lt;/sup&gt;</td>
<td>Bare area is approximated on computed tomography with use of intersecting lines</td>
</tr>
<tr>
<td></td>
<td>Distances are measured from bare area to anterior edge of osseous lesion (A) and from bare area to posterior aspect of glenoid rim (B)</td>
</tr>
<tr>
<td></td>
<td>Percent bone loss = ((B − A)/2B) × 100%</td>
</tr>
<tr>
<td><strong>Bankart length measurement</strong>&lt;sup&gt;24&lt;/sup&gt;</td>
<td>Best-fit circle with radius (R) drawn on inferior 2/3 of glenoid</td>
</tr>
<tr>
<td></td>
<td>Length of osseous lesion (x) is measured</td>
</tr>
<tr>
<td></td>
<td>If x &gt; R, dislocation resistance is ≤70% of that of an intact joint</td>
</tr>
<tr>
<td><strong>Ratio method</strong>&lt;sup&gt;23&lt;/sup&gt;</td>
<td>Best-fit circle with radius (R) is drawn on inferior 2/3 of injured glenoid</td>
</tr>
<tr>
<td></td>
<td>Distance is measured from center of circle to anterior edge of osseous lesion (d)</td>
</tr>
<tr>
<td></td>
<td>Percentage bone loss found with use of ratio d/R and specialized graph expressing percent bone loss as function of (d) and (R)</td>
</tr>
</tbody>
</table>

*A three-dimensional computed tomography scan with digital subtraction of the humeral head is best for accurate quantification.*
COMBINED GLENOID AND HUMERAL BONE LOSS

Fig. 7: When the arm is elevated, the glenoid created a zone of contact (gray zone) along the rim of the humeral head. We defined this zone as a “glenoid track.” Reprinted with permission from Yamasato N, Ito E, Abe H, Misago H, Seki N, Shima Y, Okada K. Contact between the glenoid and the humeral head in abduction, external rotation, and horizontal extension: a new concept of glenoid track. J Shoulder Elbow Surg. 2007;16:649-656.
Glenoid Track

• The contact area between the glenoid and humeral head with arm in Max ER, Max Horiz Extension, and 0 to 90 degrees Abduction

• If the Hill-Sach lesion extends medially over the glenoid track, there is a risk of engagement
Glenoid Track

• In a Healthy Shoulder Glenoid Track is 84% of the Glenoid Width

Glenoid Track

- If the Hill Sachs Lesion Stays within the Glenoid Track it will Not engage

- If the Medial Margin if a Hill-Sachs lesion is outside the glenoid track, it may engage.
Glenoid Track

• With Glenoid Bone Loss, the Track is Narrower and Small Hill Sachs Lesions can Engage
How to Account for Each Effect?

Glenoid Track

- Measure the diameter (D) of the inferior glenoid (arthroscopy or 3D CT)
- Determine the width of the anterior glenoid bone loss (d)
- Calculate the glenoid track: $GT = 0.83D - d$
How to Account for Each Effect?

Glenoid Track

- Calculate the width of the HSI, (width of the Hill-Sachs Lesion (HS))

Fig 9. The width of the Hill-Sachs lesion is measured sequentially by the 4-mm tip of the probe. The Hill-Sachs lesion has a width equal to 3 probe tips: $3 \times 4 \text{ mm} = 12 \text{ mm}$. 
How to Account for Each Effect?

Glenoid Track

- Calculate the width of the HSI, (width of the Hill-Sachs Lesion (HS) + the width of the bone bridge (BB) between the rotator cuff attachments and the lateral aspect of the Hill Sachs Lesion $HSI=HS+BB$
How to Account for Each Effect?

Glenoid Track

- $HSI = HS + BB$
- If the $HSI > GT$ then the HS is “Off Track” or engaging.
- If the $HSI < GT$ then the HS is “On Track” or non-engaging
Glenoid Track Recommendations

Table 2. Anterior Instability Categories

<table>
<thead>
<tr>
<th>Group</th>
<th>Glenoid Defect</th>
<th>Hill-Sachs Lesion</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>&lt;25%</td>
<td>On track</td>
</tr>
<tr>
<td>2</td>
<td>&lt;25%</td>
<td>Off track</td>
</tr>
<tr>
<td>3</td>
<td>≥25%</td>
<td>On track</td>
</tr>
<tr>
<td>4</td>
<td>≥25%</td>
<td>Off track</td>
</tr>
</tbody>
</table>

Table 3. Treatment Paradigm

<table>
<thead>
<tr>
<th>Group</th>
<th>Recommended Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Arthroscopic Bankart repair</td>
</tr>
<tr>
<td>2</td>
<td>Arthroscopic Bankart repair plus remplissage</td>
</tr>
<tr>
<td>3</td>
<td>Latarjet procedure</td>
</tr>
<tr>
<td>4</td>
<td>Latarjet procedure with or without humeral-sided procedure (humeral bone graft or remplissage), depending on engagement of Hill-Sachs lesion after Latarjet procedure</td>
</tr>
</tbody>
</table>

APPROACH TO GLENOID BONE LOSS
Coracoid Transfer

- Coracoid Transfer
  - Bristow
  - Latarjet
Iliac Crest Allograft

Allograft Tibial Plafond
Laterjet Results

- 2000 cases
- Recurrence 1%
- 83% RTP at Preinjury level
- 75% Excellent or Good Rowe Score

Young AA. Open Latarjet procedure for management of bone loss in anterior instability of the glenohumeral joint. JSES 2011;20:S61-S69
Laterjet Results in Bone Loss

• Case Series of 102 patients with “Pear Shaped” Glenoid and no “engaging Hill Sachs lesion underwent Open Laterjet
• 47 follow up + 55 phone interview
• Constant Score was 94.4
• 5% recurrence rate (4 had dislocation, 1 had subluxation)

Burkhart SS et al. Results of modified laterjet reconstruction in patients with anteroinferior instability and significant bone loss. Arthroscopy 23(10):1033-41, 2007
Complications of Laterjet (15-30% of patients!)

• Intraoperative
  – Graft Malpositioning (36%!)
  – Graft Fracture
  – Neurovascular Injury (10%)

• Postoperative
  – Hematoma
  – Swelling
  – Infection (6%)
  – Neuropraxia MCN
  – Brachial Plexopathy

• Long Term
  – Nonunion (9.1%)
  – Screw Removal (35% or reoperations)
  – Osteolysis of Graft (59.5%)
  – Recurrence of Instability
  – Arthritis

Iliac Crest Allograft Systematic Review

• 8 Case Series of which 3 were pooled (70 Shoulders)
  – Final Rowe Score 90.6
  – 100% integration of graft
  – 93.4% satisfied
  – 9.8% had persistent or unimproved pain
  – Recurrence was 2.9%
  – Instability in 7.1%

All Approaches for Bone Loss Systematic Review

• Six Case Series all Level IV
  – Coracoid Transfer
  – Allograft
  – Autograft

• No Technique could be recommended
• All Effective at Preventing Recurrence
• 80% RTP at same level
• Complication Rate 13.4%

Beran MC, Treatment of chronic glenoid defects in the setting of recurrent anterior shoulder instability: A systematic review JSES 2010;19:769-780
HUMERAL BONE LOSS
The Engaging Hill Sachs Lesion

Figure 1. This large Hill-Sachs lesion involves a large portion of the humeral articular surface. In this case, even without a Bankart lesion the Hill-Sachs lesion can engage the anterior corner of the glenoid, causing symptoms similar to subluxation. We call this an articular an

defect.

Burkhart S. Arthroscopy 2000;16(7):677–694
How Much Humeral Bone Loss is Important?

<table>
<thead>
<tr>
<th>Humeral head defects</th>
<th>Year</th>
<th>Percentage</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gerber and Lambert</td>
<td>1996</td>
<td>40%</td>
<td>Clinical</td>
</tr>
<tr>
<td>Miniaci and Gish</td>
<td>2004</td>
<td>25%</td>
<td>Clinical</td>
</tr>
<tr>
<td>Chen et al.</td>
<td>2005</td>
<td>20%</td>
<td>Review</td>
</tr>
<tr>
<td>Millett et al.</td>
<td>2005</td>
<td>20%-30%</td>
<td>Review</td>
</tr>
<tr>
<td>Bock et al.</td>
<td>2007</td>
<td>30%</td>
<td>Clinical</td>
</tr>
<tr>
<td>Raiss et al.</td>
<td>2008</td>
<td>21%</td>
<td>Clinical</td>
</tr>
</tbody>
</table>

**HUMERAL HEAD DEFECT > 20%**
# How Do We Measure Humeral Bone Loss?

<table>
<thead>
<tr>
<th>Humeral head</th>
<th>Radiography</th>
<th>Hill-Sachs quotient(^{17})</th>
</tr>
</thead>
<tbody>
<tr>
<td>CT (2D reconstructions in the axial, sagittal, and coronal planes)</td>
<td>Kodali et al(^{23})</td>
<td>AP view of the shoulder in 60° IR. Bernageau view (ie, Neer lateral view with 30° of cephalad tilt with the arm in maximum scapular plane elevation and 45° ER). Maximum defect width and depth are measured on each view. Volume defect = (maximum defect width on AP view) \times (maximum defect width on Bernageau view) \times (maximum defect depth on either view) Axial, sagittal, and coronal reconstruction images depicting the maximum size of the Hill-Sachs lesion. A best-fit circle is drawn using the intact humeral head circumference. Edge-to-edge distances of the defect are measured in each plane. Depth of the defect is measured in each plane with regard to the periphery of the best-fit circle.</td>
</tr>
</tbody>
</table>
APPROACH TO HUMERAL BONE LOSS
REPLISSAGE
Remplissage Results

• Of 270 patients, 59 (22%) had a <25% glenoid deficiency that were treated with Remplissage
• 45 (76%) had follow up > 2 years
• 2 of 45 (4.4%) had recurrence after dislocation
• All others had good outcome scores and were without complications

Remplissage Systematic Review
Level IV

• Eight Manuscripts – 207 Patients
• Redislocation Rate 4.2% (0-15%)
• Recurrent Instability Rate 3.2% (0-15%)
• Posterosuperior Pain and Stiffness
• Mean Reduction in ROM
  – ER in Adduction (5.6°)
  – ER in Abduction 11.3°
  – IR 0.9 vertebral levels

What to do with Humeral Bone Loss

– Elevate and Graft From Behind
– Allograft
– Metal
Glenoid Track Approach

• Group 1
  – Glenoid Defect <25%
  – Hill Sachs Lesion ON TRACK

• Arthroscopic Bankart Repair

Glenoid Track Approach

• Group 2
  – Glenoid Defect <25%
  – Hill Sachs Lesion OFF TRACK

• Arthroscopic Bankart Repair PLUS Remplisage

Glenoid Track Approach

• Group 3
  – Glenoid Defect >25%
  – Hill Sachs Lesion ON TRACK

• Laterjet Procedure

Glenoid Track Approach

• Group 4
  – Glenoid Defect ≥25%
  – Hill Sachs Lesion OFF TRACK

• Laterjet Procedure with or without humeral sided procedure (humeral bone graft or remplisage), depending on engagement of Hill-Sachs lesion after Laterjet Procedure....

My Approach

• Acute or Chronic Injury?
  – Acute with Bone Fragment
    • Smaller Fragment 0-15%-Arthroscopic Repair
    • Larger Fragment (will hold two screws)- Open Repair
  – Chronic with Bone Fragment
    • Can I elevate the Fragment and get a good repair?- Arthroscopic Consider adding Remplisage
    • Do I need to Graft? – Open, Laterjet
  – Chronic with no Bone to use
    • Open with Laterjet or if 20% or greater, Iliac Crest Autograft
My Approach

• Hill Sachs Deformity
  – <20% Nothing
  – 20-25% Remplisage
  – >25% Allograft
  – >50% (Seizure Patients- Hemiarthroplasty and use the remaining humeral head to rebuild the damaged anterior glenoid)
Thank You