1. Potential Pitfalls in Any Shoulder Instability Repair

- Glenoid bone loss – Lots of attention in recent literature
- Significant Hill-Sachs lesion
- Revision situation – post thermal cases
- Revision situation with prior capsular insufficiency
- Prior anchor placement
- Error in diagnosis
- Rehabilitation issues and compliance
- Technical errors
  - Correct anchor placement
  - Proper capsular mobilization (HAGL)
  - RI Closure?
  - Prior thermal cases?
  - Adequate capsular tensioning – 1cm?
  - HAGL injuries
- Associated injuries
  - SLAP, HAGL, bony deficiencies
  - Neurologic injury (wring!

- Boileau (JBJS 2006)\(^4\) – “Risk factors for recurrence of shoulder instability after arthroscopic Bankart repair”
  - 91 patients followed prospectively
  - 15.3% recurrence (36 months f/u), at 17 months post-surgery
  - Recurrence higher in hyperlaxity, **bone loss**, and number of anchors (4 or more was good prognostic sign)

- Tauber\(^32\) – “Reasons for failure after surgical repair of anterior shoulder instability”
  - 41 patients followed 49 months
  - At revision surgery – **56% with persistent bony defect**, patulous capsule 22%, laterally torn capsule 5%
2. Glenoid Bone Loss – Prevalence, Etiology, Classification, and History

- Burkhart and DeBeer *Arthroscopy* 2000\(^5\)
  - 21 of 194 patients with “significant” glenoid bone loss
  - Defined “Inverted Pearl” glenoid
  - 61 % failure in patients with inverted pear glenoid treated arthroscopically
- 100 CT scans of shoulder instability patients (*Sugaya JBJS 2003*)\(^28\)
  - 50% osseous Bankart lesion (1 large -27%, 27 med– 11%, 22 small – 3%)
- Location of glenoid defect – mean at 4:17 o’clock (antero-inferior). (*Saito AJSM 2005*)\(^27\)
  - Parallel to long axis of glenoid
  - At higher % defects, the line of bone loss changes somewhat to slightly more oblique
- Griffith – AJR 2008\(^9\)
  - More bone loss in recurrent instability
  - 145 patients with CT scan –
    - 0-10% bone loss – 51%
    - 10-20% bone loss – 37%
    - 20-25% bone loss – 6%
    - >25% bone loss – 6%
- Glenoid bone loss higher rate of failure after stabilization procedures (*Bigliani AJSM 1998*)\(^2\)
  - Amount and type of bone loss quantified and classified into 3 types
  - 25 patients with glenoid rim lesions were classified
  - 22 / 24 shoulder with good stability at 30 months (88%)
  - Type I (16 pts); Type II (5 pts); Type IIIA (3 pts); Type IIIB (1 pt)

◆ Burkhart and DeBeer, *Arthroscopy* 2000\(^5\)
- 194 athletes (101 rugby players) with arthroscopic Bankart Repair
- 3 metallic suture anchors on average
- 10.8% recurrence rate (21 total; 14 redislocations, 7 subluxations)
- 173 without bony defects \(\rightarrow 4\% \text{ recurrence}\)
- 21 with bony defects \(\rightarrow 67\% \text{ recurrence}\)
  - Contact athletes with bone defect \(\rightarrow 89\% \text{ recurrence}\)
- Significant bone defect = “Inverted pear glenoid” (not precisely measured, but as viewed from the anterosuperior portal the inferior diameter of the glenoid was smaller than the superior diameter”)\(^{17}\)

Conclusion: Patients with significant bone defects, especially contact athletes are not candidates for arthroscopic repair
  - Approximately 11% had significant glenoid bone defects
• **Patient History** – low threshold for glenoid bone loss suspicion especially if (Piasecki, Provencher, Romeo et al; *JAAOS* 2009, in print):
  - Long-term instability
  - Multiple dislocations
  - Mechanical clunk
  - Multiple reductions/ER reductions.
  - Progressive ease of dislocation and also reduction
  - History of self reduction (Not MDI)
  - Instability symptoms in mid-ranges of motion

3. **Glenoid Bone Loss - Biomechanics**

   - Biomechanics: Itoi (*JBJS* 2000)\(^{15}\) – glenoid defects anteroinferiorly of >21% (mean 6.8 mm) causes persistent instability and limit ER after Bankart repair.

Sequential osteotomies

<table>
<thead>
<tr>
<th>ABER: Capsular structures held</th>
<th>ABIR: Shoulder</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 21% bone loss</td>
<td>subluxated easily</td>
</tr>
</tbody>
</table>

- However, he demonstrated stability in **ABER position due to competent capsular constraints**. ABD&IR allowed to subluxate.

**CONCLUSION**: Glenoid Defects >21% (approx 6.8 mm) may cause continued instability and limit ER after Bankart Repair (especially with capsular repair)

⇒ **Clinical Applicability**: What is also inferred from Itoi’s work is that in up to a 21% bone defect, the capsular restraints will potentially be enough for stability when adequately repaired
### Biomechanical Implications of Glenoid Bone Loss

- ↓ glenohumeral stability
  - ↓ articular arc length = ↓ balance stability angle
  - ↓ articular arc depth = ↓ concavity-compression stability

- ↑ glenohumeral contact pressures

- ↑ surgical failure rates (*if not addressed appropriately*)
  - ↑ shear forces seen by isolated soft-tissue repairs = ↑ failure rates

### 4. Quantifying Glenoid Bone Loss

**Radiographic:**

- Axillary view and also true AP of the glenohumeral joint may offer “hint” of subtle bone loss
- Easier to see large losses. Body habitus, radiographic quality (axillary esp.), and other factors may inhibit determination of amount of glenoid bone loss by plain radiography

- **Special axillary views** that are helpful:

  - Apical oblique – Garth *JBJS* 1984
  - West Point View – Roukis and Feagin *CORR* 1972
    - Itoi *AJSM* 2003: cadaveric glenoids utilized to create glenoid bone defects, and West Point and CT scan compared.
    - 21% defect was 18.6% on the West Point
    - 21% defect was 50% of width on single slice (axial)

- Sugaya et al. *JBJS* 2003
  - 100 instability shoulder with CT scan studied
  - Defect measured based on CT scan and digitized the inferior 2/3rds of the glenoid
    - The inferior 2/3rds of glenoid is consistently a “circle”


Gold Standard to assess bone loss is by 3D CT scan, with humeral head digitally subtracted.

- Loss of circle bone comprises amount (percent) of bone loss.
- Conclusions – Radiographic Measurements:

1. CT scan remains the gold standard for determination of bone loss
2. Large Majority of instability patients have some form of bone loss (erosion or “attritional” versus bony fragment)

◆ Arthroscopic Measurements

• Lo, Parten & Burkhart, “The inverted pear glenoid: An indicator of significant glenoid bone loss” Arthroscopy 2004

  ▪ Cadaveric study and clinical study (53 patients) to evaluate amount of glenoid bone loss arthroscopically
  ▪ termed “inverted pear glenoid” when viewed from anterosuperior portal.
  ▪ Correlated with cadaveric measurements
  ▪ Based upon measurements from the glenoid bare spot

<table>
<thead>
<tr>
<th>Distance from bare spot</th>
<th>In Vivo (mm) “X”</th>
<th>Cadavers (mm) “X”</th>
</tr>
</thead>
<tbody>
<tr>
<td>Posterior glenoid rim</td>
<td>11.4</td>
<td>12.3</td>
</tr>
<tr>
<td>Anterior glenoid rim</td>
<td>10.3</td>
<td>12.1</td>
</tr>
<tr>
<td>(normal)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inverted pear</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>vs. 3.3 mm (inverted pear) = 35%</td>
<td></td>
</tr>
</tbody>
</table>

Easy formula to calculate – with scope from anterosuperior portal:
% Bone Loss = \( \frac{\text{Amount of bone loss in mm}}{2 \times \text{distance from posterior glenoid rim to bare spot in mm}} \times 100 \)

- Bare spot as accurate reference is disputed:
  - Kralinger Arthroscopy 2006\(^{16}\)
  - 20 embalmed cadavers –
  - Bare spot to anterior rim: 10.9 mm
  - Bare spot to posterior rim: 13.7 mm
  - May not be accurate determination of bone loss
  - Criticism - embalmed specimens may not accurately represent the bare spot
- Griffith – AJR 2008\(^9\)
- Bone loss between CT scan and arthroscopy show high correlation
- Provencher – AJSM 2008\(^{23}\) – Arthroscopic measurement errors
  - No difference in a clinical bone loss model (bone loss parallel to the long axis of the glenoid) in measurement with:
    - 2 different posterior portals
    - Different trajectories

5. Glenoid Bone Loss – Treatment Algorithm

*** Clinical suspicion remains paramount! ****

- Low threshold to obtain advanced imaging to assess for glenoid bone loss with the following (not all inclusive):
  - Prior failed instability procedure
  - Multiple prior instability events, multiple subluxations or dislocations
  - Long history, chronic instability (> 6 months?)
  - Trivial trauma for first instability event (glenoid hypoplasia)
  - Bilateral history of shoulder instability
  - Plain film suggestion of bony glenoid deficiency

- Best to know ahead of time your operative plan, as surgical technique is based upon the amount of glenoid bone loss

6. Glenoid Bone Loss – Treatment Options

- Based upon preoperative or intraoperative determination of bone loss
- Key: How to obtain a successful stabilization procedure with minimal losses of motion

- Nonoperative
  - Smaller fragments
  - Lower demand individuals
• Maquieira (JBJS-Br 2007) found no redislocations in 14 patients with >5 mm bone fracture treated nonoperatively

• **Arthroscopic Repair**
  • Glenoid bone loss less than 20 to 25%
  • Can be successful
  • Provencher et al (2007)\(^{19}\) – results better with incorporation of bony fragment
  • Sugaya et al (2006)\(^{29,30}\) – bony lesion, if repaired with arthroscopic techniques can heal to more normal/near anatomic position
    • Reconstitutes the bone loss of glenoid
    • Better if more acute injury
    • Less predictable if attritional/erosion loss

• **Open Repair without Bony Augmentation**
  • Described for open capsulolabral repair to address bone loss
    ▪ Probably similar to arthroscopic repairs, potentially higher success?
    ▪ 0/14 recurrences in open repair procedure\(^{20}\)
  • Open repairs – screw fixation of acute fractures\(^{31}\)

• **Bone Augmentation Procedures**
  • Glenoid bone loss of potentially any amount
  • Especially in loss >20-25%
  • Variety of options and techniques
  • **Arthroscopic bone grafts**
  • **Arthroscopic coracoid transfer**
    • **Open bone grafts**
      • Coracoid transfer
        • Bristow – “tip” of coracoid
        • Latarjet – larger piece of coracoid
        • Management of the “Latarjet” – can be confusing
        • Many “ways” to do a Latarjet
          • Subscapularis tendon management
            ▪ Split longitudinal
            ▪ Complete take-down
          • Conjoint tendon management
            ▪ Leave on as a “sling”
            ▪ Reattach to remnant coracoid
          • Orientation of the coracoid
            ▪ Lateral edge (traditional) or inferior edge (Burkhart) as the glenoid face
            ▪ With INFerior edge as glenoid face:
              • More bone to work with – up to 14mm
Better congruity of the glenoid and humerus (REF)

“Fits better” – Figure:

- Iliac crest bone graft
  - Large inner table shelf
  - Haaker$^{10}$ (Mil Medicine); Warner$^{33}$
  - Can be utilized for very large defects
- Allograft
  - Concerns of noncontained graft incorporation in the past
  - Femoral head allografts have been shown to heal (1996 data)$^{12}$
  - May be option in future? Have to demonstrate efficacy, healing, and capsular management

**New advancement - Allograft Option Recently Described:**

- Fresh osteochondral distal tibia allograft as an alternative to fresh glenoid
- Prior difficulty obtaining fresh glenoid allograft (contamination and harvest issues)
- Investigated novel application of distal tibia to the glenoid (REF)
  - Exceptional fit and near perfect radius of curvature to the humeral head and glenoid (REF)
  - Figure:
    - Fresh – weight bearing bone; excellent corticocancellous fixation
    - As of Sept 2009, have performed 7 cases, most over 10 months out, all with documented healing on CT scan (axial images) and full return to military duties
    - Still “investigational” as prior allograft concerns are evident, however, this represents **new fresh allograft technique** to the glenoid.
      - No prior graft processing (radiation, sterilization)
      - Excellent weight-bearing bone
      - Basic science and clinical evidence that the bone “fits” well
Glenoid Bone Loss Management
AOSSM Specialty Day 2013

Glenoid Mapping:
Ghodadra, Provencher et al. 2009

Near identical radius of curvature, cartilage thickness, and surface area replaced
From: Ghodadra, Provencher, Romeo et al. 2009

- Other bone grafts
  - J-bone graft from Iliac Crest to glenoid
  - Femoral head allograft (AJSM 2009)
References:


Additional Reading and Resources


