B2 Glenoid: Anatomic Reconstruction – Bone or Augment

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Current Solutions in Shoulder and Elbow Surgery
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I have something to disclose.

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“My Academy” app;

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Goals of Anatomic TSA

• Correction of pathologic bony deformity (retroversion)
• Restoration of native joint line
• Balancing of the soft tissues
• Centering of the humeral head
• Is this possible with moderate to severe glenoid bone loss (B2 glenoid)?
Options for Correction of Posterior Glenoid Bone Loss in TSA

- Ream the high side: Limit of 15-20° correction of retroversion
- Cases that exceed this limit (B2 glenoid):
  - Full correction leads to joint line medialization and/or peg perforation, narrowed glenoid
  - Incomplete correction may have negative consequences


What is the Consequence of Incomplete Correction?

- Ho et al, JBJS 2013: Significance of retroverted glenoid
  - 66 TSA cases with press-fit pegged glenoid component
  - Mean f/u: 3.8 yrs (range, 2-7)
  - 20 cases (30%) with osteolysis of center peg
  - ≥15° of component retroversion associated with 5-fold increase odds of osteolysis around center peg
  - No correlation to worse clinical outcome

What is the Consequence of Incomplete Correction?

- B2 glenoid with posterior humeral head subluxation associated with poorer TSA outcomes compared with other glenoid types.
  - 12% revision for glenoid loosening, instability (mean 77 mos)
  - 66.3% very satisfied or satisfied
  - 20% radiographic loosening (56% shifted):
    - Significantly higher preoperative retroversion, posterior humeral head subluxation in loose glenoids.
    - Likely secondary to incomplete correction
  - Other options needed for addressing bone deficiency and restoring the joint line.

Denard & Walch, JSES 2013
Walch et al, JSES 2012
Options for Correction of Posterior Glenoid Bone Loss in B2 Glenoid

- Mild bone loss:
  - High-side reaming may be possible
  - Use of posterior augment: bone graft vs. augmented component
- Moderate to severe bone loss:
  - Use of a posterior augment: bone graft vs. augmented component
  - Reverse TSA ± bone graft
- Achieves goals of component placement

Bone Graft Augmentation

- Use of humeral head autograft in primary TSA:
  - Matched articular surface vs. step-cut
  - Technically demanding
  - Bone incorporation needed for long-term implant stability
- Clinical results mixed in several case series:
  - Small numbers, heterogeneous
  - High radiolucency rates
  - Complications with graft preparation, fixation, and incorporation

Bone Graft Augmentation

<table>
<thead>
<tr>
<th>Study</th>
<th>Patients</th>
<th>Mean Age</th>
<th>Male/Female</th>
<th>Graft Source</th>
<th>Stem Orientation</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hsu et al. (2011)</td>
<td>24</td>
<td>65.8</td>
<td>21/3</td>
<td>Allograft</td>
<td>Reverse</td>
<td>92%</td>
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<td>Huang et al. (2009)</td>
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<td>8/2</td>
<td>Allograft</td>
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<td>8/2</td>
<td>Allograft</td>
<td>Reverse</td>
<td>90%</td>
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<tr>
<td>Stephens et al. (2015)</td>
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<td>65.5</td>
<td>8/2</td>
<td>Allograft</td>
<td>Reverse</td>
<td>90%</td>
</tr>
</tbody>
</table>

59% 0-54% 11-71%

Bell & Noble, JSES 2000

Stephens et al., JBJS 2015
Augmented Component

• Biomechanical & modeling data show ability to address bone loss, recreate joint line
• Early clinical outcomes appear favorable
• Three commercially available implants

Augment Non-Clinical Data

• Biomechanical comparison of four augmented glenoid designs to standard anchor peg glenoid.
  - Resistance to anterior glenoid lift-off from posterior eccentric load assessed.
  - Stepped glenoid significantly more stable than wedge shaped designs.

Augment Non-Clinical Data

• Computational model to compare three available designs in B2 glenoids.
  - Amount of bone removal and bone quality remaining assessed
  - Correction to 0° vs. 10° retroversion
• Posterior wedge design:
  - Significantly less bone removal
  - Significantly greater residual glenoid bone density posteriorly
• Wright et al, Bull HJD 2015: Wedge augment for posterior glenoid wear vs. standard glenoid without posterior wear
  - Age and sex matched (24 pts/group), mean f/u 29.4 mos (min 24 mos)
  - No difference in pain, outcome score improvement between groups:
    - No complications in either group
    - 1 augmented component radiographically loose
    - 17/20 augmented components centered on axillary view, 3/20 anteriorly subluxated

• Favorito et al, JSES 2016: Stepped augment for posterior glenoid wear
  - 22 pts, mean f/u 36 mos (20 B2, 2 C)
  - Significant improvement in function, outcome scores
  - 1/22 central peg osteolysis
  - 2/22 implant instability

• Stephens et al, JSES 2016: Stepped augment for posterior glenoid wear
  - 21 pts, mean f/u 35 mos (19 B2, 2 C)
  - Significant improvement in function, outcome scores
  - 1 central peg osteolysis
  - No complications

• Evaluate post-operative correction of glenoid pathology and humeral head alignment in TSA using three-dimensional computed tomography (3-D CT) analysis.
  - Compare by:
    - Implant type (standard or augmented glenoid component)
    - Glenoid morphology (Walch classification)
Methods
- 88 patients with advanced glenohumeral osteoarthritis underwent TSA with polyethylene anchor peg glenoid component:
  - 3-D CT pre-operatively planning
  - Glenoid component type:
    - 57: standard (APG)
    - 31: posteriorly augmented (STEP)
  - Tantalum marker bead (1 mm) embedded in peripheral pegs for implant tracking
- Evaluated with pre-operative CT and post-operative CT within 3 months of surgery.

Results
- STEP vs. APG comparison for B2/B3 glenoids:
  - Version correction significantly greater with STEP (11.9±6.6° vs. 3.6±3.8°, \( p<0.001 \)).
  - Correction of pathologic joint line significantly greater with STEP (1.1±2.0 mm vs. -0.7±1.8 mm lateralization, \( p=0.005 \)).
  - Trend for better post-operative HGA with STEP (0.4±3.2% vs. -1.3±2.7%, \( p=0.083 \)).
  - Significantly greater correction of posterior humeral head subluxation relative to premorbid anatomy with STEP (20.4±7.4% vs. 13.6±6.9%, \( p=0.001 \)).
CCF Clinical Series

- 108 consecutive shoulders
- 2 Fellowship-trained surgeons
- Anatomic TSA with Augmented Glenoid for Primary OA
- Jan 2010 – Nov 2014

70 Shoulders
3-D preop CT
2 yr. follow-up

108 consecutive shoulders
2 Fellowship-trained surgeons
Anatomic TSA with Augmented Glenoid for Primary OA
Jan 2010 – Nov 2014

55 shoulders
Walch B2 or B3

70 Shoulders
3-D preop CT
2 yr. follow-up

CCF Clinical Series

- 64 ± 7 years old (range, 51-80)
- 43/55 (78%) Male
- Median FU 2.6 years (range, 2-5.6)
- 34 (62%) B2, 21 (38%) B3

PREOP POSTOP P-value

<table>
<thead>
<tr>
<th></th>
<th>PREOP</th>
<th>POSTOP</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Penn Score</td>
<td>24 [13-43] (5-54)</td>
<td>93 [64-97] (51-100)</td>
<td>&lt;0.0001</td>
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<tr>
<td>Version</td>
<td>-25°±7° (-43° – -12°)</td>
<td>-12°±7° (-30° – 1.3°)</td>
<td>&lt;0.0001</td>
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<tr>
<td>Centered?</td>
<td>10/55 (18%)</td>
<td>45/55 (81%)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Forward Flexion</td>
<td>110° [90°-130°] (70°-160°)</td>
<td>160° [146°-170°] (90°-180°)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>External Rotation</td>
<td>20°±16° (0°-60°)</td>
<td>50°±14° (10°-80°)</td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>

Mean ± Std Deviation (Range), Median [Interquartile Range] (Range), Number (Percentage%)

2 Complications/Reoperations – Subscapularis repair 6 months postop,
Scope for painful TSA 2 years postop – unknown etiology

CCF Clinical Series
### Conclusions

- Bone graft, augmented component both options for treatment of B2 glenoid.
  - Bone graft: mixed results in literature
    - Technically challenging
    - Bone graft size, quality variable
  - Augmented component: promising early clinical results
    - Reproducible surgical technique, defined corrections (augment sizes)
    - Ability to correct pathology (version, joint line, humeral head subluxation)
    - Longer follow-up needed to assess maintenance of correction over time, impact on component loosening
    - Limits to pathology can correct (B3 glenoid)?
Case Presentation (B2)

- 63 year-old male with advanced glenohumeral arthritis and B2 glenoid, rotator cuff intact

- Maintaining joint line with correction of version:
  - Standard glenoid vs. 5 mm augmented glenoid
Case Presentation (B2)

Humeral Head Autograft
Augment Clinical Data

- Three clinical series in literature to date:
  - Wright et al, Bull HJD 2015 (wedge)
  - Favorito et al, JSES 2016 (posterior step)
  - Stephens et al, JSES 2016 (posterior step)

- All done for posterior wear, all show improvement in pain, function, outcome scores:
  - Wright et al: No difference age and sex matched

- No difference in pain, outcome score improvement between groups:
  - No complications in either group
  - 1 augmented component

Results

- B2 glenoids with STEP compared to A1 glenoids with APG:
  - Similar correction to premorbid version (within -2.2±6.3° vs. -1.8±4.1°, STEP vs. APG, p=0.839).
  - Similar joint line correction (1.1±2.0 mm vs. 1.2±1.4 mm, STEP vs. APG, p=0.822)
    - STEP did not correct to premorbid joint line in B2s as much as APG in A1s (-1.2±2.2 mm vs. 0.9±1.0 mm, p<0.001).
  - Post-operative HGA was similar between groups (0.4±3.2% vs. -1.1±4.0%, STEP vs. APG, p=0.154).