Total Shoulder Arthroplasty for Active Adults using a Novel Inlay Glenoid

John E. Zvijac, M.D.
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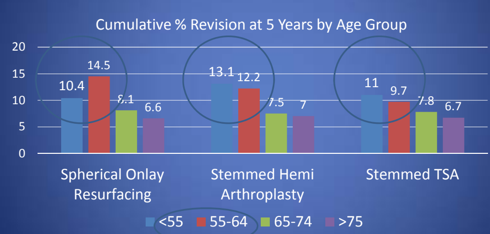
2016 Australian Shoulder Arthroplasty Registry



Source: Tables SP14, SP33, ST24

Reported Results

- Humeral head resurfacing
- Viable treatment option in young, active patients
- Low revision rates
- Good mid-term result
- **NO GLENOID**

Savoie, et al. OJSM 2014 2(1) 1-7
Bailie, et al. JBJS 2008:90:110-17

The UHZ Experience with Total Shoulder Resurfacing

An analysis of clinical and radiographic outcomes with the Arthrosurface HemiCAP OVO system

John E. Zvijac, M.D.

UHZ Sports Medicine Institute

Outline

- Background
  - History
  - Rationale
  - Indications
  - Technique and Pearls
- Results
- Discussion

History

- Steffee and Moore reported on the first humeral resurfacing procedures in the late 1970's
  - Used a hip implant
  - Later modified to more closely match humeral head dimensions
- Early prostheses were made out of stainless steel and had no central stem
- Fixation was via methylmethacrylate cement
- **No glenoid resurfacing** at this time

Burgess, et al. Current Concepts Review: Shoulder Resurfacing. *JBJS Am*. 2009; 91:1228-1238

History

- Copeland began developing a cementless surface replacement
- Initial designs used a screw through the lateral cortex of the humerus
- Many designs have abandoned the screw in favor of a stem
- Most have hydroxyapatite or ceramic porous coating to encourage bone ingrowth

Burgess, et al. Current Concepts Review: Shoulder Resurfacing. *JBJS Am*. 2009; 91:1228-1238

History

- Partial resurfacing is a somewhat newer concept
- A tapered post is mated to a headless cannulated screw
- Useful for treatment of asymmetric chondral defects

Burgess, et al. Current Concepts Review: Shoulder Resurfacing. *JBJS Am*. 2009; 91:1228-1238

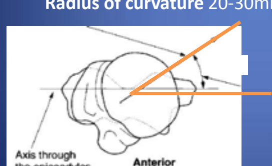
Rationale

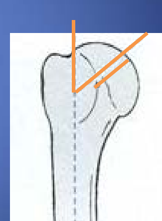
"Normal" shoulder anatomy can vary substantially among individuals and even between shoulders of the same individual

Retroversion 0-55°

Inclination 30-55°

Radius of curvature 20-30mm





Burgess, et al. Current Concepts Review: Shoulder Resurfacing. *JBJS Am*. 2009; 91:1228-1238

Rationale

Failure to reproduce anatomy can diminish outcomes in several ways

- Retroversion/Inclination
  - Changes tension and/or lever arm of deltoid and rotator cuff muscles
    - Instability
    - Decreased range of motion
    - Weakness
- Radius of Curvature
  - Change of 5mm may decrease ROM by 20-30°
  - May increase extent of glenohumeral translation

Burgess, et al. Current Concepts Review: Shoulder Resurfacing. *JBJS Am*. 2009; 91:1228-1238

Humeral Head Shape

Iannotti JP, Gabriel JP, Schneck SL, Evans BG, Misra S.

The normal glenohumeral relationships. An anatomical study of one hundred and forty shoulders.

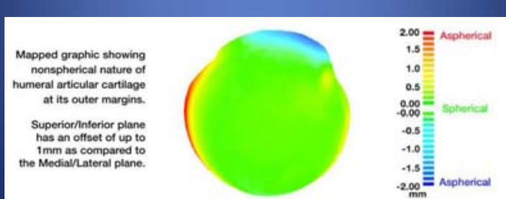
J Bone Joint Surg Am. 1992 Apr;74(4):491-500.

JBJS The Journal of Bone & Joint Surgery

- **The humeral articular surface was spherical in the center, however, the peripheral radius was two millimeters less (or 4mm on the diameter) in the axial plane than in the coronal plane.** Thus, the peripheral contour of the articular surface was elliptical (or Ovoid in 3D).
- The radius of curvature of the glenoid, measured in the coronal plane, was an average of 2.3 $\pm$ 0.2 millimeters greater than that of the humeral head.

HH is less spherical at its margins

- Spherical and aspherical off-the-shelf offsets provide the closest match to human anatomy
- Using spherical implants may cause overstuffing of the joint – loss of ROM



Rationale

Failure to reproduce anatomy can diminish outcomes in several ways

- Glenohumeral offset
  - Impingement with glenoid rim or acromion
  - Increased tension on rotator cuff muscles
  - Decreased range of motion

Burgess, et al. Current Concepts Review: Shoulder Resurfacing. *JBJS Am*. 2009; 91:1228-1238

Rationale

- Resurfacing allows restoration of native anatomy
  - Humeral neck, > 50% of humeral head are maintained
  - No osteotomy, so head-shaft angle is maintained
  - Accurate guide-pin placement recreates anatomic version and inclination
  - Preoperatively planning for radius of curvature and center of rotation allow for appropriate implant selection
  - Many authors reported that offset, version, inclination area maintained with resurfacing, though Thomas et al. noted an offset increase by a mean of 5mm

Thomas, et al. Geometrical analysis of Copeland surface replacement shoulder arthroplasty in relation to normal anatomy. *JSES*. 2005;14:186-192.

Burgess, et al. Current Concepts Review: Shoulder Resurfacing. *JBJS Am*. 2009; 91:1228-1238

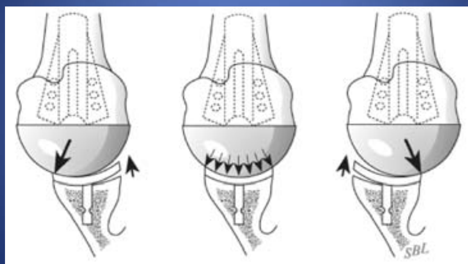
History

- Initially traditional glenoid designs were used
  - Keeled
  - Pegged
  - Metal-backed
  - Cemented

Burgess, et al. Current Concepts Review: Shoulder Resurfacing. *JBJS Am*. 2009; 91:1228-1238

Rationale

Failure Mode: Rocking Horse Phenomenon

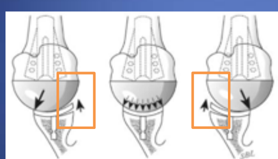


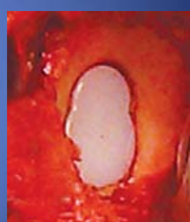
Matsen FA, et al. Glenoid Component Failure in Total Shoulder Arthroplasty
JBJS Am. 2008;90:885-896.

Rationale

Failure Mode: Rocking Horse Phenomenon

Solution: Inlay Glenoid





Matsen FA, et al. Glenoid Component Failure in Total Shoulder Arthroplasty
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Finite element analysis and physiologic testing of a novel, inset glenoid fixation technique

S. Gunther, M.D. et al, JSES 2012

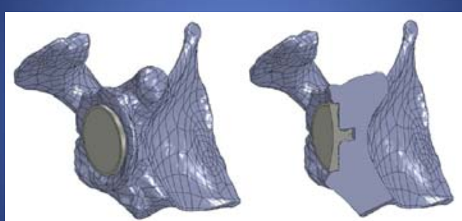
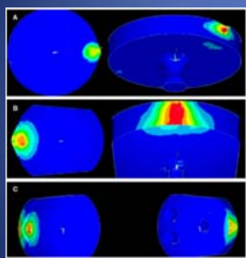


Figure 1. Representation of a glenoid implant inset within the glenoid cavity and a cross section of the glenoid implant inset into the glenoid cavity.

Finite element analysis and physiologic testing of a novel, inset glenoid fixation technique

S. Gunther, M.D. et al, JSES 2012



Distraction values more significant in both onlays than inset

Stress concentrations were highest along periphery of onlays vs inset

Both of which contribute to rocking-horse phenomenon

Finite element results at the superior edge of the glenoid implants: (A) circular inset implant, (B) keeled onlay implant, and (C) pegged onlay implant.

Inlay vs. Onlay

A Comparison of Two Glenoid Systems in Total Shoulder Arthroplasty

ORS

2015

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CLEMSON BIOENGINEERING

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MANUSCRIPT Accepted at JSES

Purpose

Examine the contact pressures and implant stability associated with fatigue loading during physiological loading and motion in cadaveric model.

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Implants:

- Inlay glenoid (Arthrosurface)
- Onlay glenoid (DJ Ortho)

Material and Methods

- 8 matched pair cadaveric shoulders (n=16)
- Biomechanical testing in abduction angle of 60 degrees
- Anterior-Posterior cyclic fatigue loading with 333.6 N for 4000 cycles in all specimen or until clinical loosening was observed

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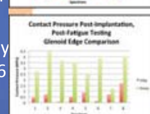
Results

- Onlay: Significantly higher pressures on the edge of the glenoid
- Inlay: Load sharing with the native tissue
- All Onlays were clinically loose at a mean of 1126 cycles
- None of the Inlays were clinically loose after 4000 cycles (predetermined endpoint)



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Indications

- Etiologies
  - OA
  - RA
  - Post-traumatic arthritis
  - AVN
  - CTA
  - Chronic instability
- Pain and/or decreased function that has failed nonoperative management
- Extra-articular humeral deformities or hardware

Burgess, et al. Current Concepts Review: Shoulder Resurfacing. *JBJS Am*. 2009; 91:1228-1238.

Surgical Technique

- Deltopectoral approach
  - Internervous plane
  - Incision in the axillary fold
- Antero-superior approach (described by Mackenzie)
  - Splits deltoid in anterior raphe
  - Easier glenoid access

Molé D et al. Surgical technique: the anterosuperior approach for reverse shoulder arthroplasty. *Clin Orthop Relat Res*. 2011; 469:2461-8.

Burgess, et al. Current Concepts Review: Shoulder Resurfacing. *JBJS Am*. 2009; 91:1228-1238.

Surgical Technique

- Subscapularis is divided about 1cm from its insertion
- Tips for exposure and reaming
  - Inferior capsule is released along humeral neck for 1-2cm inferiorly while arm is externally rotated to 90º
  - Pectoralis tendon can be partially released
  - Glenoid rim and humeral neck osteophytes must be completely removed
  - Use 3-4 Hohmann retractors around the humeral head once it is dislocated

Burgess, et al. Current Concepts Review: Shoulder Resurfacing. *JBJS Am*. 2009; 91:1228-1238.

Surgical Technique

- Glenoid reaming is a particular challenge with unresected humeral head
- Tips for glenoid exposure and reaming
  - Shoulder retractors
    - Fukuda
    - Double-prong glenoid retractors
    - Darrach elevator
  - Low profile glenoid reamer

Burgess, et al. Current Concepts Review: Shoulder Resurfacing. *JBJS Am*. 2009; 91:1228-1238.

The UHZ Experience

An analysis of clinical and radiographic outcomes with the HemiCAP OVO system

- Collect demographic, radiographic, and outcome data
- **Goals**
  - **Evaluate the restoration of native anatomy**
    - **Length of Glenohumeral Offset**
    - **Quantify Humeral Head Deformity**
    - **Determine Implant's Ability to Restore Native Anatomy**
  - **Assess clinical outcome via validated scoring systems**
    - **Effect of degree of deformity on these outcome measures**

Materials and Methods

- Imaging assessed
  - Preoperative xrays
  - Postoperative xrays obtained in clinic
    - No intraoperative or immediate postoperative imaging

Does Resurfacing Implant Restore Anatomy?

1. Does this implant accurately reproduce **preoperative** anatomy?

2. Does this implant accurately restore **"normal"** anatomy?

Materials and Methods

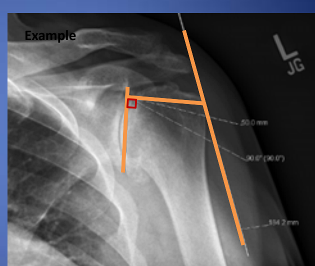
- Mechlenburg et al. published a study utilizing a modified Length of Glenohumeral Offset (LGHO)

- Intra- and Inter-tester reliability were found to be very high in their study

Mechlenburg et al. The Copeland resurfacing humeral head implant does not restore humeral head anatomy. A retrospective study. *Arch Orthop Trauma Surg*. 2013; 133:615-619.

Materials and Methods

- Measurements performed using calibrated PACs system
- Modified Length of Glenohumeral Offset (LGHO) was measured using technique described by Mechlenburg et al.
- Restoration of preoperative anatomy was defined as restoration of the modified LHGO



Mechlenburg et al. The Copeland resurfacing humeral head implant does not restore humeral head anatomy. A retrospective study. *Arch Orthop Trauma Surg*. 2013; 133:615-619.

Materials and Methods

1. Does this implant accurately reproduce preoperative anatomy?
 - Modified Length of Glenohumeral Offset

2. Does this implant accurately restore **"normal"** anatomy?
 - Quantify the degree of humeral head deformity
   - Measured radius of curvature (ROC)
   - **Predicted** "normal" ROC
   - Difference is degree of deformity
   - Compare this to implant ROC

Materials and Methods

The normal glenohumeral relationships. An anatomical study of one hundred and forty shoulders

JP Iannotti; JP Gabriel; SL Schneck; BG Evans; S Misra

J Bone Joint Surg Am. 1992 Apr 01;74(4):491-500

JBJS The Journal of Bone & Joint Surgery

- Measured the dimensions of glenohumeral joint and articular surfaces of 140 shoulders
  - 96 in cadavers, 44 on MRIs of living patients
- Multiple relationships were defined relating different humeral head measurements
- These included neck/shaft angle, humeral head height, radius of curvature, and glenohumeral offset

Materials and Methods

The normal glenohumeral relationships. An anatomical study of one hundred and forty shoulders

JP Iannotti; JP Gabriel; SL Schneck; BG Evans; S Misra

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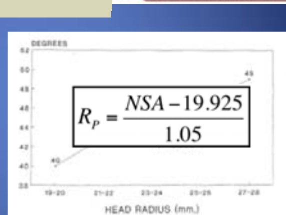
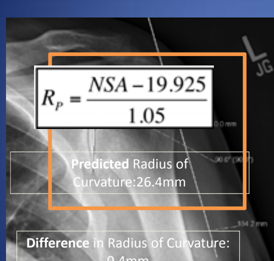
JBJS The Journal of Bone & Joint Surgery

- One pair specifically exhibited a nearly linear relationship
- These data points were matched with a line of best fit, which provided an equation for radius of curvature as a function of a measured neck/shaft angle



$$R_p = \frac{NSA - 19.925}{1.05}$$

Materials and Methods

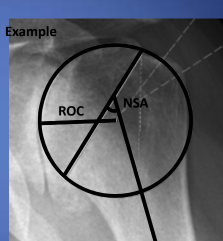


$$R_p = \frac{NSA - 19.925}{1.05}$$

Predicted Radius of Curvature:26.4mm

Difference in Radius of Curvature: 0.4mm

This value quantifies the degree of deformity preoperatively



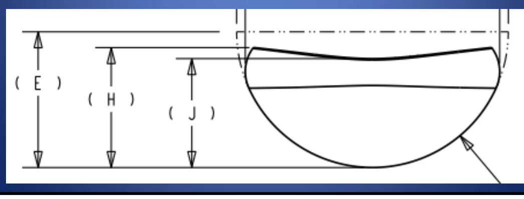
Measured Neck-Shaft Angle: 47.6

Measured Radius of Curvature: 26.8

Materials and Methods

- Look at the implant's ability to restore normal anatomy
- Compare radius of curvature data for humeral head implant
  - Patient's actual preop ROC
  - Patient's predicted normal ROC

Implant Size	Radius of Curvature (mm)
46x42	22.987
48x44	24.003
50x46	24.003
52x48	25.984
54x50	27.000
56x52	27.991
58x54	28.981



Materials and Methods

- Summary of Measured Data
  - Preoperative modified LGHO
  - Postoperative modified LGHO
  - Humeral Head Neck-Shaft Angle
  - Preoperative Humeral Head ROC
  - Implant ROC (provided by manufacturer)
  - Outcome Scores

Results

- Surgeries performed Oct 2011-Oct 2013
- All Performed for DJD
- 30 Left, 26 Right
- 60 shoulders in 54 patients met inclusion criteria
  - 2 shoulders had inadequate imaging
  - 3 patients withdrew their consent
- 56 Shoulders in 50 patients were evaluated

Conclusions

- Arthrosurface humeral head implant does not reproduce "preoperative anatomy" in patients with severe HH deformity
  - Average difference between implant ROC and preoperative ROC was 1.9mm
  - This difference was 4.3mm in patients with more preop deformity, a statistically significant increase
- Arthrosurface humeral head implant does reproduce "normal anatomy" in all patients
  - The difference between implant ROC and predicted "normal" humeral head ROC was just 0.1mm on average
  - More severe humeral head deformity does not result in a statistically significant difference in implant and predicted "normal" ROC
- Using my method to calculate radius of curvature (and knowing the radius of curvature for the implants) may improve implant selection

Prospective Clinical Results Following Inlay Glenoid Replacement in Total Shoulder Arthroplasty

UHZ Sports Medicine Institute

Clinical Study

- To evaluate the use of an inlay glenoid resurfacing in conjunction with a stemless humeral head component
- Consecutive series of patients with advanced glenohumeral arthritis who failed prior conservative treatment.

Demographics

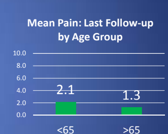
- Enrollment: n=93 shoulders
  - 7 bilateral patients
  - 60 male, 33 female
- Average Age: 64.6 years (range: 25-81)
- Diagnosis: DJD/OA (92), AVN (1)
  - Secondary Dx (n=21): Biceps Pathology (11), Arthrofibrosis (2), RTC Tear (8)
  - Duration of Symptoms: 87 > 6months, 8 < 6 months

Intraoperative

- Operative Time: Mean 136 min (range: 70-300)
- Blood Loss: Mean 111 ml
- No transfusions required
- All shoulders treated with OvO humeral head resurfacing and glenoid inlay arthroplasty

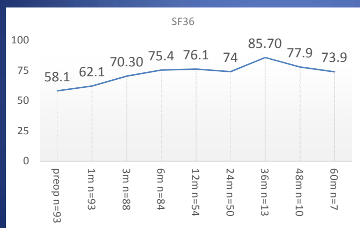
Results: VAS Pain

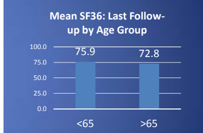
Full Cohort



Mean FU: 35.8 mo	Mean FU: 32.5 mo
Mean Age: 55.1	**Mean Age: 71.6**
Range: 25-64	Range: 65-81

Results: SF-36 (Rand)

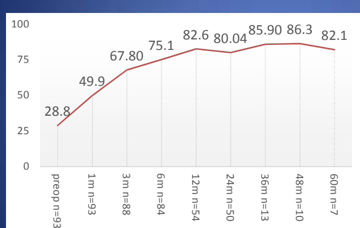


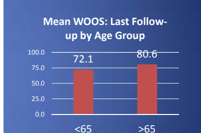


Mean FU: 35.8 mo
Mean Age: 55.1
Range: 25-64

Mean FU: 32.5 mo
Mean Age: 71.6
Range: 65-81

Results: WOOS

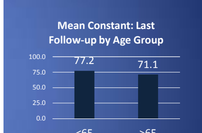




Mean FU: 35.8 mo
Mean Age: 55.1
Range: 25-64

Mean FU: 32.5 mo
Mean Age: 71.6
Range: 65-81

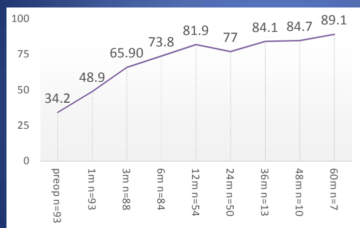
Results: Constant

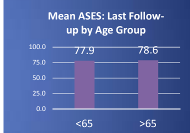


Mean FU: 35.8 mo
Mean Age: 55.1
Range: 25-64

Mean FU: 32.5 mo
Mean Age: 71.6
Range: 65-81

Results: ASES





Mean FU: 35.8 mo
Mean Age: 55.1
Range: 25-64

Mean FU: 32.5 mo
Mean Age: 71.6
Range: 65-81

Complications

- 2 Infections - P. Acnes
  - S. Aureus
- Glenoid Removed
- 1 Cuff Tear – Subscapularis
- 2 Scopes > 1 Year Out

Conclusion

- Inlay glenoid replacement combined with humeral head resurfacing arthroplasty is a viable alternative to standard stemmed TSA with a traditional onlay glenoid replacement.
- Our cohort achieved significant improvement in patient relevant metrics
- High patient satisfaction

Take Home Messages

- Reproducible technique based on individual anatomy
- Bone stock preservation for procedures
- Minimal impact on soft tissues including RTC and subscap repair
- No lateralization of the glenoid
- Lower intraoperative morbidity than stemmed procedures
- Excellent recovery and reassuring 2 year data

Thank You

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