

Humeral Implant Stress Shielding Issues

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Disclosure

- Wright Medical----consulting , royalties

Stress shielding- Stress shielding is characterized by adaptation of the bone to the altered stress distribution following Wolff's law, resulting in the bone's becoming either thinner (external remodeling) or more porous (internal remodeling).

Proximal stress shielding is decreased with a short stem compared with a traditional-length stem in total shoulder arthroplasty

Patrick J. Denard, MDa,b,*; Matthew P. Noyes, MDa; J. Brock Walker, MDc; Yousef Shishani, MDd; Reuben Gobeze, MDd; Anthony A. Romeo, MDe; Evan Lederman, MDc,f

- Traditional length stems demonstrated 74% cortical thinning and 31% partial calcar resorption compared to 50% thinning and 23% resorption for shorter stem of same design
- No functional difference between long
 - And short stems



Not just length but Diaphyseal Design



- Stress shielding- Stress shielding is characterized by adaptation of the bone to the altered stress distribution following Wolff's law, resulting in the bone's becoming either thinner (external remodeling) or more porous (internal remodeling).
- Hip AML whether clinically apparent depends on starting bone mass
- Long diaphyseal- arthrex study but not in promos
- Short stems too- Walch ascend Filling ratio useful to compare size effect
- Filling ratio not the whole story
- Collar might help
- Longitudinal loading or bending/torsion?
- Technique could be important- smaller size, bone grafting?-

Diaphyseal design Promos design

- Nagels J, Stokdijk M, Rozing PM. Stress shielding and bone resorption in shoulderarthroplasty. *J Shoulder Elbow Surg* 2003;12:35-39. doi:S1058-2746(02)00002-2
- Wirth MA, Lim MS, Southworth C, Loredro R, Kaar TK, Rockwood CA. Compaction bone-grafting in prosthetic shoulder arthroplasty. *J Bone Joint Surg Am* 2007;89:49-57. doi:10.2106/JBJS.E.01069

Radiologic bone adaptations on a cementless short-stem shoulder prosthesis

Marc Schnezke, MD^{a,*}, Sebastian Coda, MD^b, Patric Raiss, MD^c, Gilles Walch, MD^d, Markus Loew, PhD^e
J Shoulder Elbow Surg (2016) 25, 650-657

- No Loosening
- High Bone adaptations 51.9%
- Cortical Thinning Osteopenia 82.7%
- Spot Weld Lateral Cortex 78.6%
- High Filling ratios in metaphysis and diaphysis associated with high bone adaptations



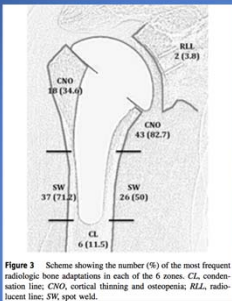
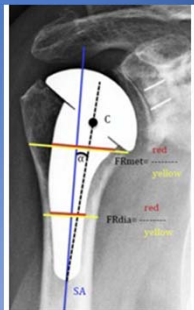
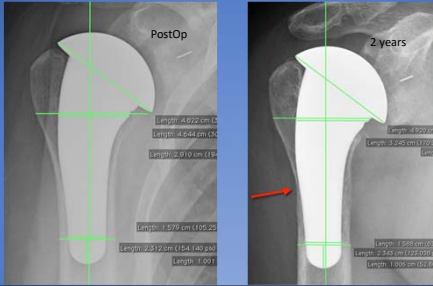


Figure 3 Schema showing the number (%) of the most frequent radiologic bone adaptations in each of the 6 zones. CL, condensation line; CNO, cortical thinning and osteopenia; RL, radiolucent line; SW, spot weld.



Lateral Humeral Bone Resorption



ORIGINAL ARTICLE

Radiographic changes differ between two different short press-fit humeral stem designs in total shoulder arthroplasty

Patrick J. Denard, MD^{1,2,3}, Matthew P. Noyes, MD¹, J. Brock Walker, MD¹, Yousef Shishani, MD¹, Reuben Gobeze, MD¹, Anthony A. Romeo, MD¹, Evan Lederman, MD¹

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 The Cleveland Shoulder Institute, Beachwood, OH, USA
 Rush University Medical Center, Chicago, IL, USA
 The Orthopaedic Clinic Association, Phoenix, AZ, USA

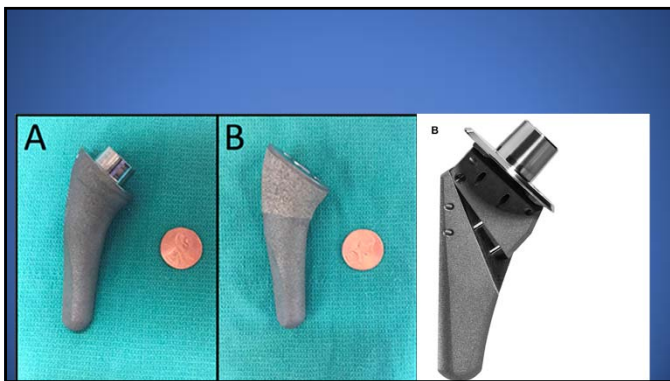
Background: The purpose of this study was to compare the radiographic changes of the humerus in the short term after total shoulder arthroplasty with two different short-stem humeral components. The hypothesis was that there would be no difference in radiographic changes or functional outcome based on component type.

Methods: A retrospective review was conducted of primary total shoulder arthroplasties performed with a short press fit humeral component. Group A included a variable humeral stem with an oval geometry and curved stem (Anatomical or Anatomical Flex, Wright Medical, Memphis, TN, USA). Group B included a humeral stem with a metaphyseal collar, rectangular geometry, and straight stem (Cares, ArthroS, Inc., Naples, FL, USA). Radiographic changes and functional outcome were evaluated at a minimum of 2 years postoperatively.

Results: There were 42 patients in group A and 33 patients in group B available for analysis. There was no difference in functional outcome between the groups. In group A, the mean total radiographic change score of the humerus was 2.6, with changes classified as low in 38% and high in 62%. In group B, the mean total radiographic change score of the humerus was 3.5, with changes classified as low in 7% and high in 23% ($P < .001$). Multivariate analysis was performed in 17% of group A component and 26.2% of group B ($P < .001$). Conclusion: At short-term follow-up, there is no difference in functional outcome or outcome between 2 different humeral stem designs. However, bone adaptive changes and the rate of medial collar resorption are significantly different.

Level of evidence: Level III, Retrospective Cohort Design, Treatment Study
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Keywords: Total shoulder arthroplasty; short stem; humeral loosening; stress shielding; press fit; bone resorption; metaphyseal fixation



Collared rectangle versus oval stem

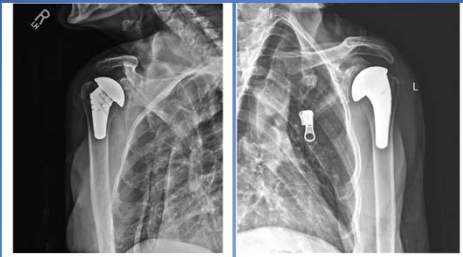


Figure 4 The 2-year postoperative radiograph of an individual in group B with an Apex stem shows partial medial calcar osteolysis.

Figure 3 The 2-year postoperative radiograph of an individual in group A with an Accol Fx stem shows partial medial calcar osteolysis.

28%

71%

Reverse shoulder arthroplasty with a cementless short metaphyseal humeral implant without a stem: clinical and radiologic outcomes in prospective 2- to 7-year follow-up study

Levy, O., et al. *Journal of Shoulder and Elbow Surgery*
2016

- Excellent Results, 106 patients
- No loosening
- No lucencies
- No stress shielding



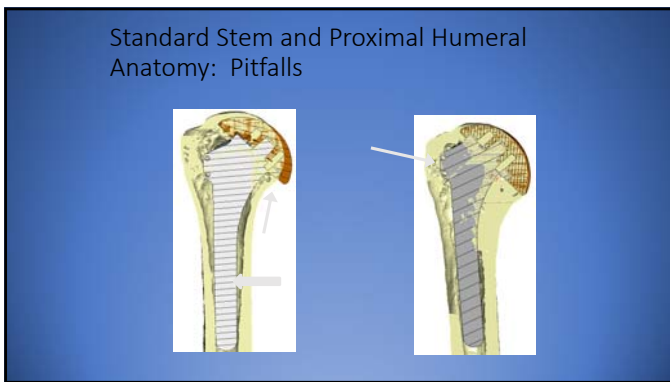
Humeral bone resorption after anatomic shoulder arthroplasty using an uncemented stem

Kazuya Inoue, MD, PhD^{1,2}, Naoki Suenaga, MD, PhD¹, Naomi Ozumi, MD, PhD¹, Hiroshi Yamaguchi, MD, PhD¹, Naoki Miyoshi, MD¹, Noboru Taniguchi, MD, PhD¹, Mitsuru Munemoto, MD, PhD¹, Takuya Egawa, MD¹, Yasuhito Tanaka, MD, PhD¹

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Multiple manufacturers
85% partial bone resorption
18% full thickness cortical resorption
Greater tuberosity, lateral diaphysis, medial calcar
Risk Factors:
female, HHR with cuff reconstruction, large filling ration, on growth stem coating





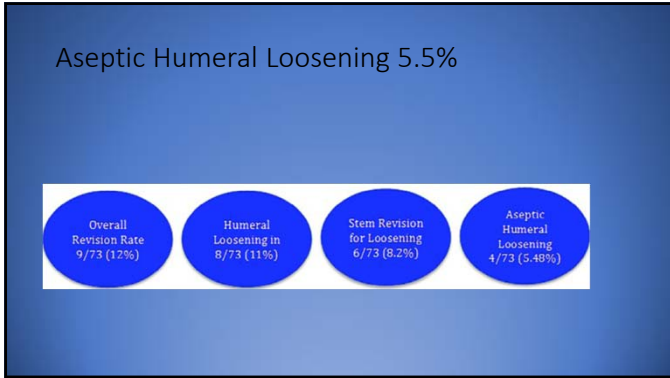
Stu

Radiographic evaluation of short-stem press-fit total shoulder arthroplasty: short-term follow-up

Danielle J. Casagrande, MD*, Di L. Parks, MD, Travis Torngren, MD, Mark A. Schrupf, MD, Samuel M. Harmsen, MD, Tom R. Norris, MD, James D. Kelly II, MD

J Shoulder Elbow Surg (2016) 25, 1163–1169


- Evaluate the short to medium term radiographic outcomes of a press-fit short stem primary TSA
- 72 Shoulders
- 2 Surgeons
- F/U 24-50 Months



Reverse Total Shoulder Arthroplasty: A Review of Results According to Etiology

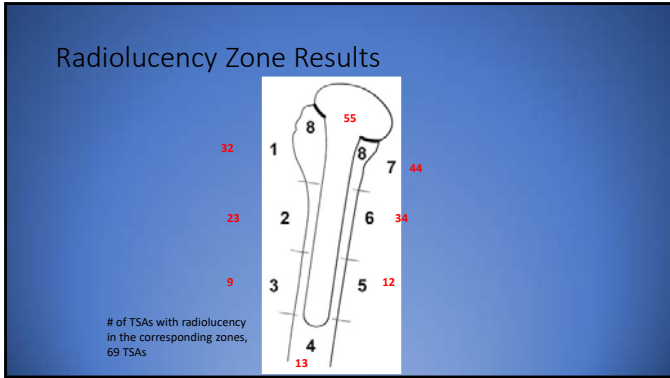
Bryan Wall, Laurent Nové-Josserand, Daniel P. O'Connor, T. Bradley Edwards and Gilles Walch
J Bone Joint Surg Am. 2007;89:1476-1485. doi:10.2106/JBJS.F.00666

- Cemented Grammont Stems
 - 1/137 (.7 %) Loosening



Stem Radiolucency Results

- Stem Radiolucency (based on 69 TSAs in final radiographic follow-up group)
 - Y—63 (91.3%)
 - N—6 (8.7%)
- Stems at Risk (based on 69 TSAs in final radiographic follow-up group)
 - Y—10 (14.5%)
 - N—59 (85.5%)



Calcar Osteolysis

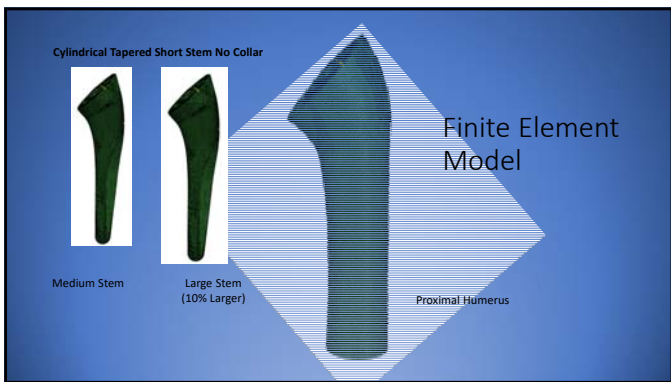
- Based on 69 TSAs in final radiographic follow-up group
- Complete—3 (4.3%)
- Partial—16 (23.2%)
- None—50 (72.5%)

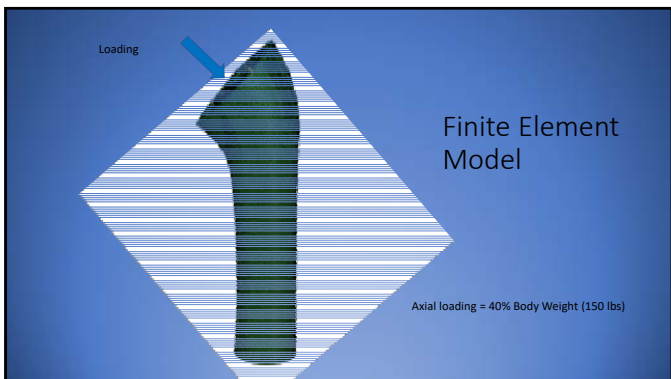
Complete calcar osteolysis at 36 months postop

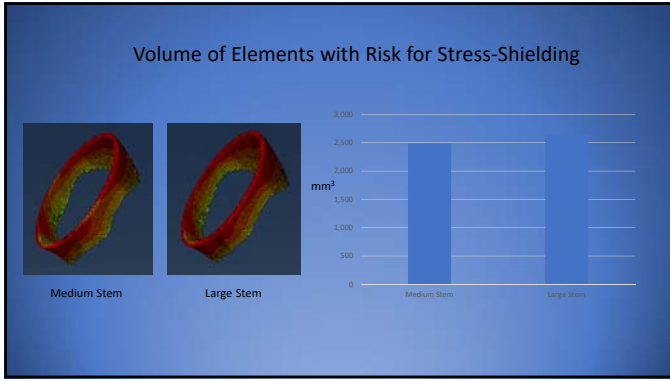
Diaphyseal v Metaphyseal

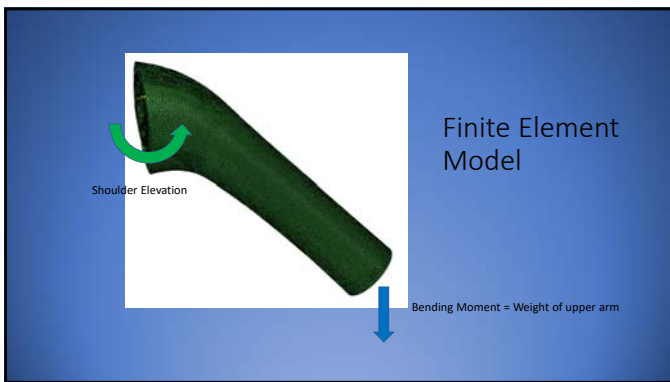
- Stress Shielding can be seen in both diaphyseal and metaphyseal designs
- Filling ratio can be a significant factor but its design again is important

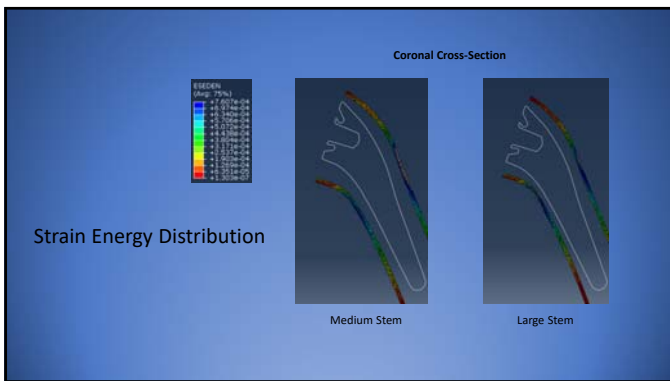
Effect of Short Stem Size on Humerus Stress-Shielding

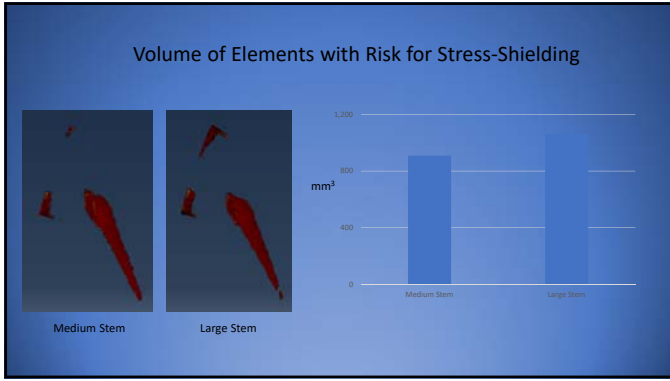


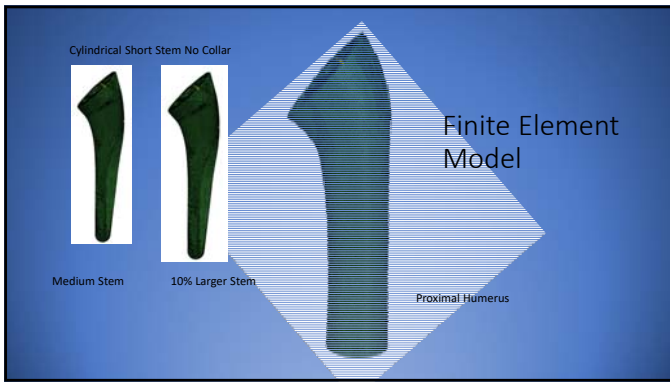


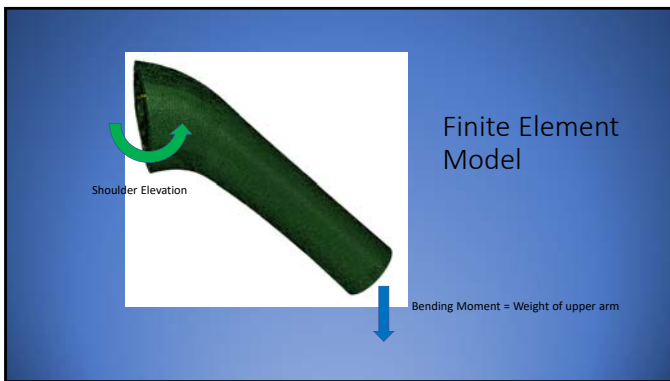


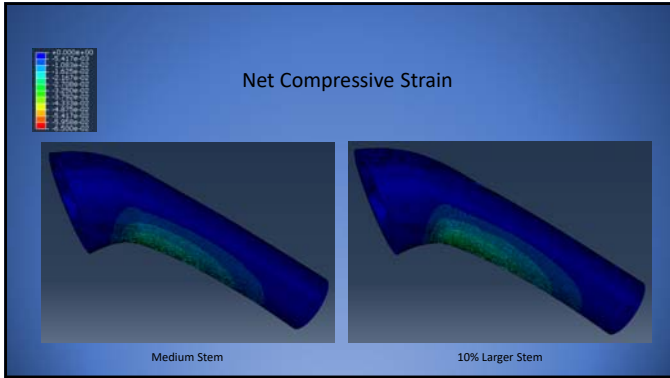


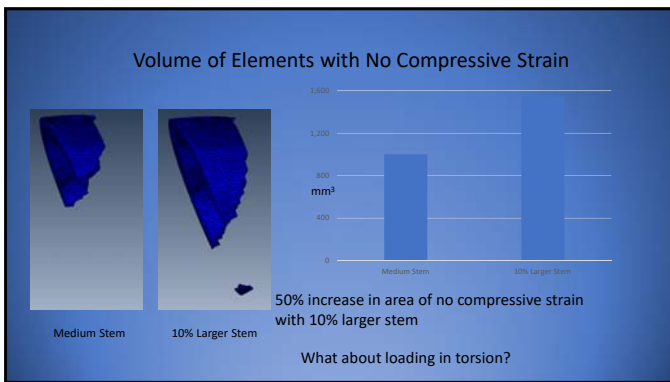












Long-term results of uncemented humeral components in shoulder arthroplasty

Olivier Verborgt, MD, PhD,^{a,b} Rami El-Abiad, MD,^{a,c} and Dominique F. Gazielly, MD,^a Paris, France, Bruges, Belgium, and Beirut, Lebanon

- 37 Neer II Components
 - 9.2 Years
 - 14% Tilted
 - 19% At risk for loosening
 - No Revisions
 - Prevalence of at risk components not associated with pain or decreased function.

Journal of Shoulder and Elbow Surgery, 16(3),

Total Shoulder Arthroplasty Utilizing Mini-Stem Humeral Components: Technique and Short-Term Results
 Patrick W. Jost, MD · Joshua S. Dines, MD · Matthew H. Griffith, MD · Michael Angel, MD · David W. Altchek, MD · David M. Dines, MD

HSSJ (2011) 7:213-217

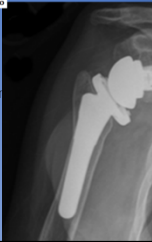
- 49 Mini Stems
- No Loosening reported
- 11/49 < 1mm lucent lines
- Good to excellent clinical results



SHOULDER AND ELBOW
 Short-stem uncemented primary reverse shoulder arthroplasty
 CLINICAL AND RADIOLOGICAL OUTCOMES

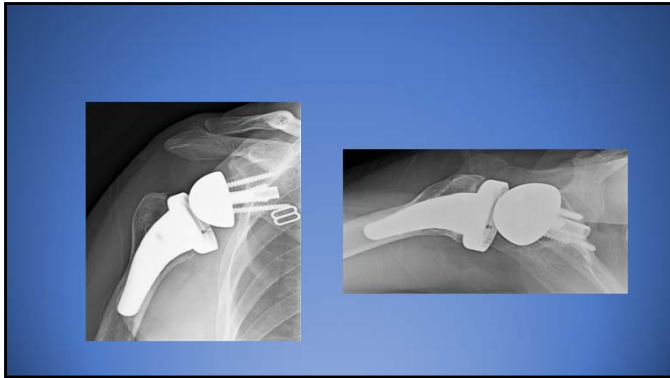
Bone Joint J 2014;96-B(526-9): S. A. Guseff, P. Sreazbel, J. Sperling, J. Sanchez-Sotelo

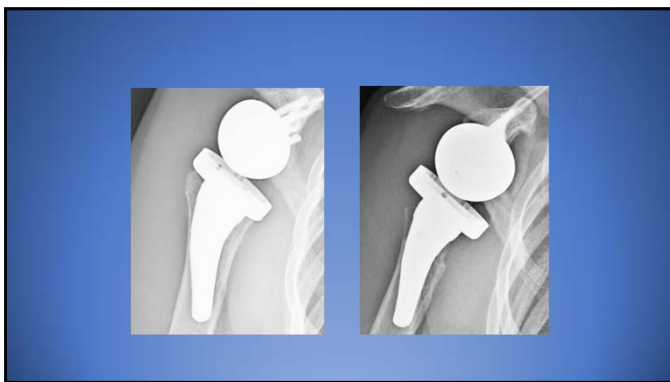
- 44 patients
- No Loosening
- 29.5% proximal humeral remodeling
 - One patient subtotal tuberosity resorption
 - ?Diaphyseal Fixation
 - ?Metaphyseal Fixation

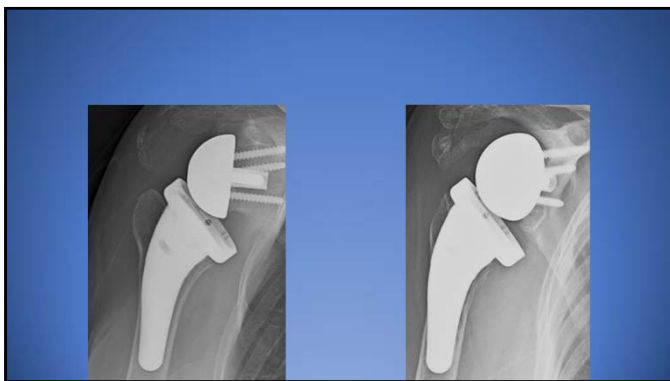


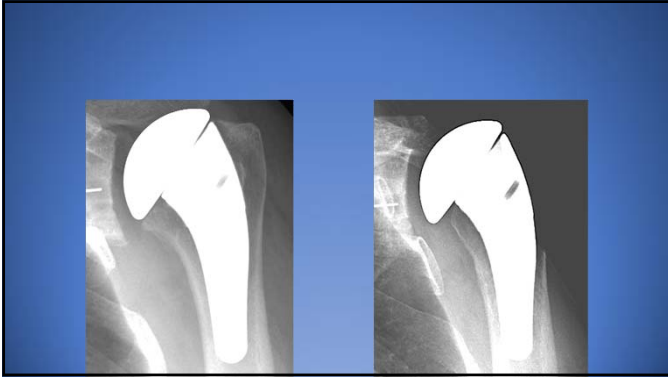
Proximally Coated Porous Stem
 122 Shoulders

- Similar Reproducible Excellent Results
- Loosening: 2/122 (1.6%) [5.4%]
- Radiolucent Lines: 9/122 (7.4%) [91%]
- Stem at Risk: 2/122 (1.6%) [14.5%]
- Calcar Osteolysis: 35/122 (28.7) [27.5%]
- **Severe Lateral Cortical Thinning 13/122 (10.6%)**
 - < 1mm remaining lateral cortex















How can we prevent stress shielding especially in osteoporotic patients with large canal?

- Know the potential for the implant design being used
- Minimize oversizing
 - Consider cement augmentation
 - Consider bone grafting to rebuild bone and use a smaller size implant?

Compaction Bone-Grafting in Prosthetic Shoulder Arthroplasty

By Michael A. Wirzb, MD, Moon-Sup Lim, MD, Carlton Southworth, MS, Rebecca Lomaha, MD, T. Kenneth Kass, MS, MD, FRCS, FRCS(Orth), and Charles A. Rockwood Jr., MD
Investigation performed at the University of Texas Health Science Center at San Antonio, San Antonio, Texas

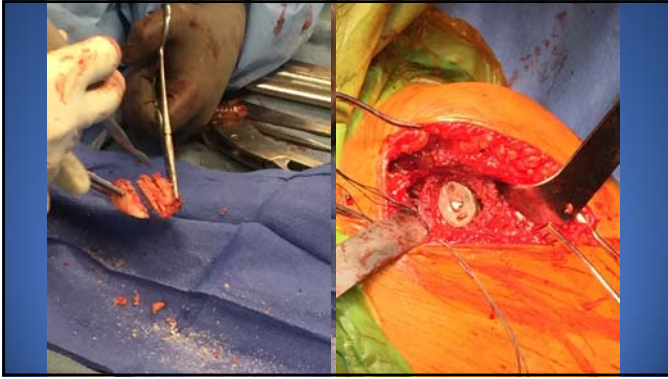
Background: Compaction bone-grafting has been suggested as a means of improving the stability of the humeral component in shoulder arthroplasties, but the clinical and radiographic results of the procedure have not been reported in the literature, to our knowledge. To address this deficit, we report on a series of shoulder arthroplasties performed with compaction bone-grafting to secure humeral component fixation. These prostheses were implanted in shoulders demonstrating a suboptimal interference fit of the humeral component.

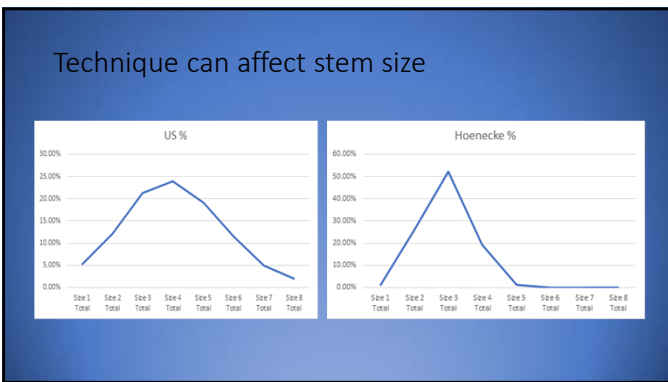
Methods: Fifty-eight shoulders in fifty-three patients were treated with prosthetic shoulder arthroplasty that included compaction bone-grafting. Clinical assessments were performed at regular intervals with use of visual analog scales for pain, shoulder comfort and function, and overall quality of life, and with use of patient self-assessments including the American Shoulder and Elbow Surgeons Score and the validated Simple Shoulder Test. A detailed radiographic analysis was performed by three raters to determine whether radiolucent lines were present immediately postoperatively and at a later follow-up interval. The humeral tilt angle was determined by measuring the angle between the humeral axis and the component. Subsidence was also evaluated. The mean of the raters' measurements was used in the analysis.

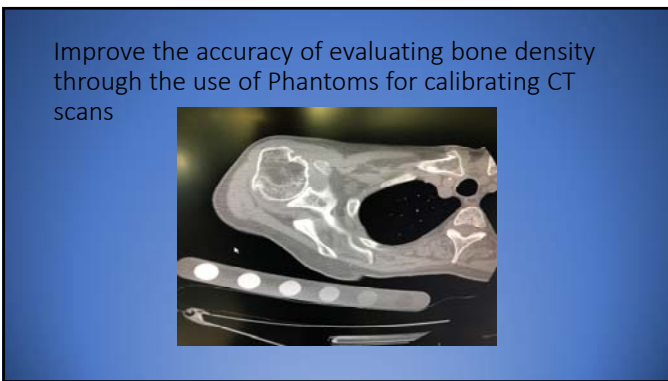
Results: The mean duration of follow-up was sixty-nine months (range, twenty-six to 148 months). No loose stems were observed, and no humeral component was revised. At the time of follow-up, there was significant improvement in the Simple Shoulder Test scores and all visual analog scores ($p < 0.0001$ in each instance). Thirty-four stems had no radiolucent line at the time of follow-up, and the mean maximum thickness of the lucent lines was 0.21 mm in the entire group of fifty-eight shoulders. Most lucent lines occurred near the distal stem tip. The mean tilt of the valgus and varus humeral components was 2.2° and 2.0°, respectively, on the immediate postoperative radiographs. No humeral component shifted from varus to valgus or vice versa. The duration of follow-up was not correlated with the maximum thickness of the humeral component lucency, and the presence or absence of a prosthetic glenoid was also unrelated to the maximum thickness of the lucency.

Conclusions: Compaction bone-grafting in shoulder arthroplasty can yield stable and durable fixation of the humeral component, as seen clinically and radiographically, without use of cement. Our findings provide evidence that compaction bone-grafting in shoulder arthroplasty is an option to ensure intermediate-term fixation (at a mean of five years) of humeral components that have a suboptimal fit.

Level of Evidence: Therapeutic Level IV. See Instructions to Authors for a complete description of levels of evidence.







Summary

- Bone adaptations occur in all stems even if not visible on xray
- Filling ratio can be a significant factor but design is important
- Collar might have an effect
- Bending moments might be more important than longitudinal loading
- Technique might play a role in the potential for bone adaptations
- Bone mass available at the time of implantation is important
