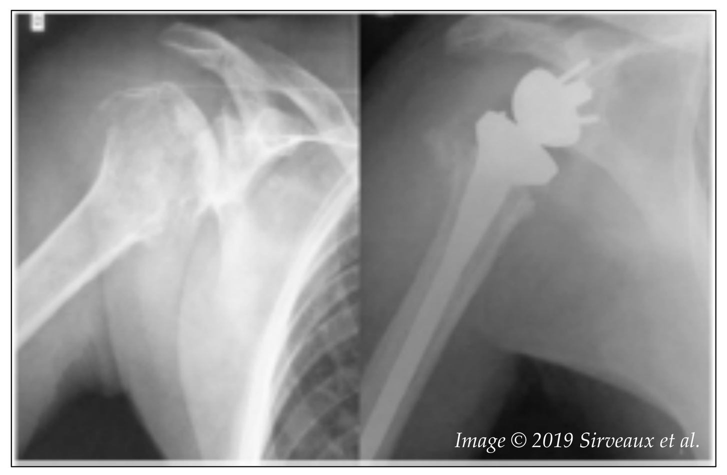
# Reduced Cementation in the Setting of Reverse Shoulder Arthroplasty with Proximal Bone Loss: A Biomechanics Study

Carlos Maturana, MS, Brendan Shi, MD, Shannon Wu, BS, Brandon Peterson, MS, Tyler R. Clites, PhD, Thomas J. Kremen, MD
*Anatomical Engineering Group, University of California Los Angeles*

# Introduction

## Background and Motivation

There is no consensus on the appropriate degree of cement application in cases of significant proximal bone loss (fracture) or resection (tumor). It is known that extensive cementation of a humeral prosthesis makes eventual revision arthroplasty more challenging.



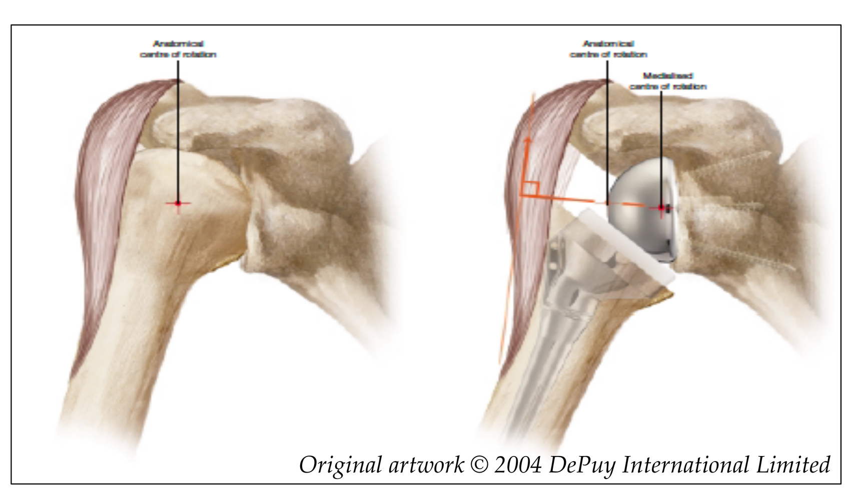

**3rd most common**
*fracture in patients 65 yrs. and older [1]*

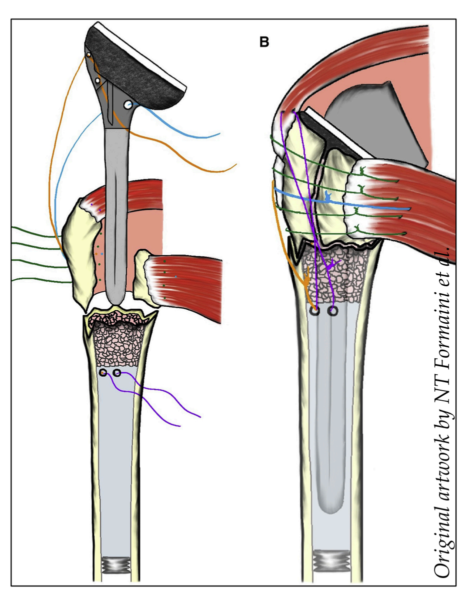
**755% increase**
*in demand by 2030 for patients 55 yrs. and older [2]*

**As low as 58%**
*functional survival after 10 years post-op [3]*

"Humeral component removal can be challenging with iatrogenic fracture occurring in up to one fourth of cases." – Chalmers et al., 2018

## Reverse Shoulder Arthroplasty




Reverse shoulder arthroplasty (RSA) is mainly indicated when the resection involves the rotator cuff. RSA is a viable option if the deltoid muscle and axillary nerve are spared.

**5 cm** has been previously shown as the threshold for **bone-allograft** in RSA surgery. [4] We adopted this approach in our experiment.

## Cementation & Revisions

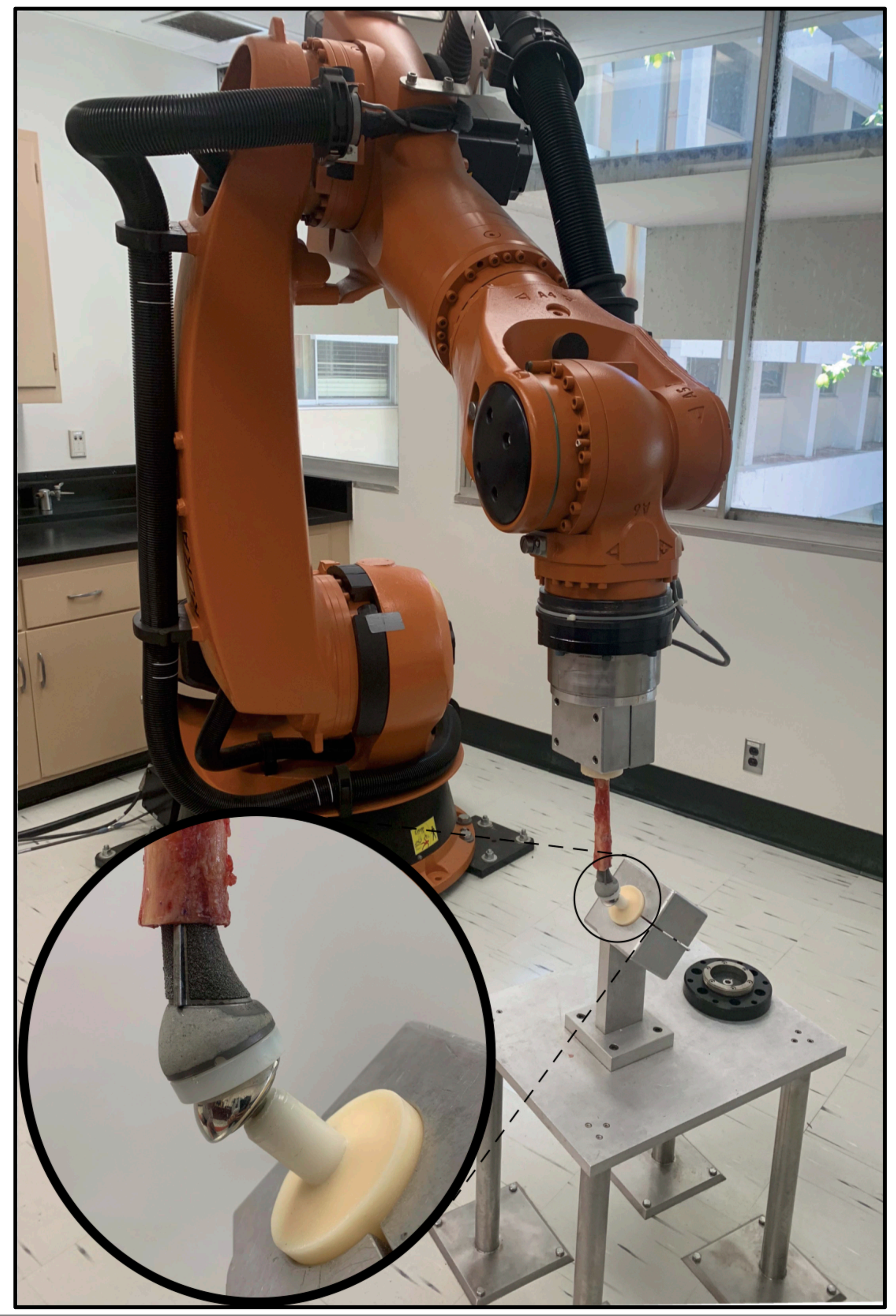
**Revision Surgery:** 5 to 12% revision rate in RSA for proximal humerus fractures. **Dislocations** and **infections** are the most common reasons. [5]

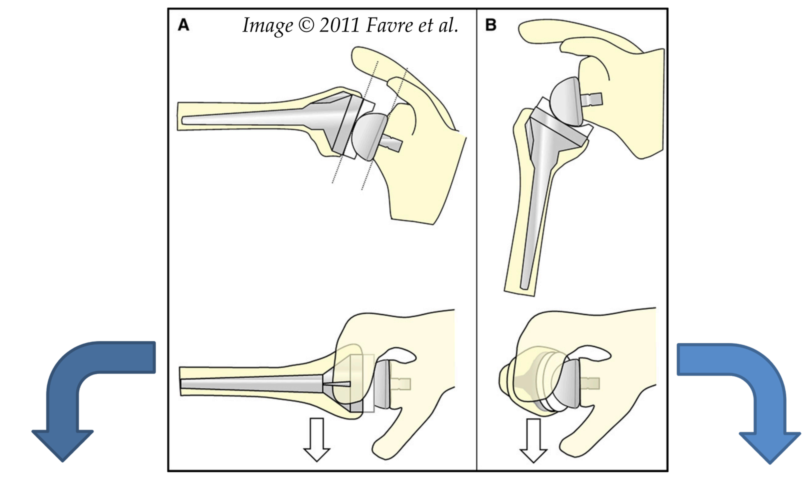


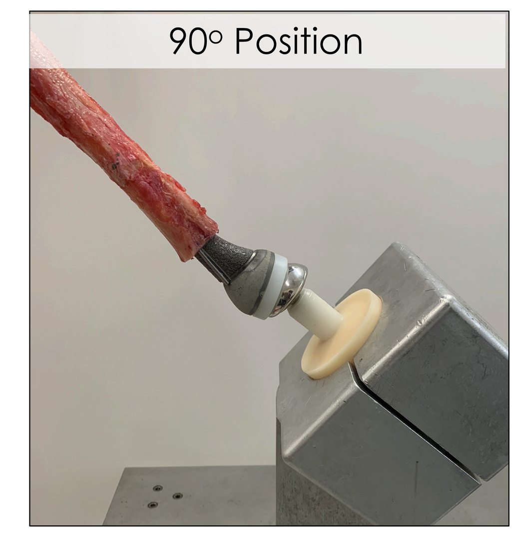
**Cementation:** Polymethyl Methacrylate (PMMA) is applied in **excess** around the prosthesis to improve stability.

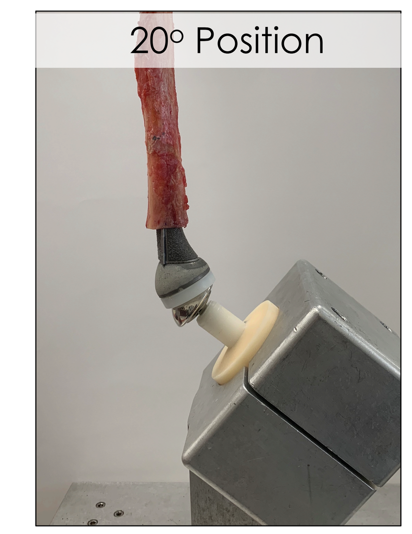
We hypothesize that **2cm of proximal cementation** will provide sufficient biomechanical stability and ease of revision.

# Kinematic Analysis Using Robotic Arm (KUKA)





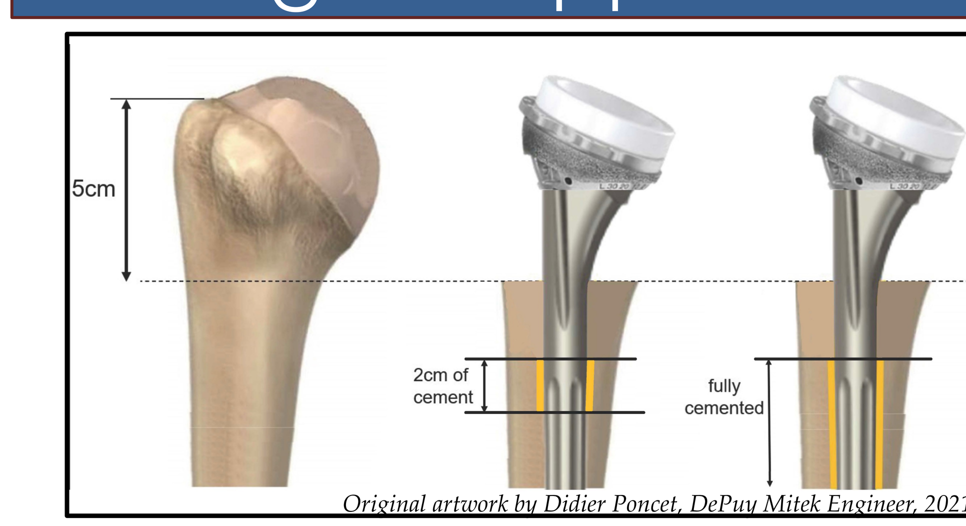




The KUKA provides accurate kinematic analysis around 6-degrees of freedom (DOF). It can measure component displacement down to **100 microns** and provides user-controlled torque analysis. The KUKA will allow us to evaluate 1) the degree of implant **subsidence** in relation to the amount of cementation used and 2) the required **removal torque** to separate the implant from the humerus.

# Cadaveric Experimental Methods

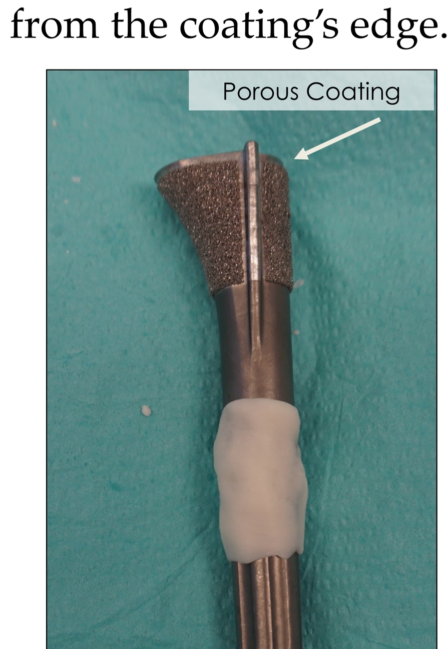
## Surgical Approach




Matched humeral pairs were proximally resected 5cm from the greater tuberosity to simulate fracture with bone loss. Samples were reamed to size using standard surgical technique.

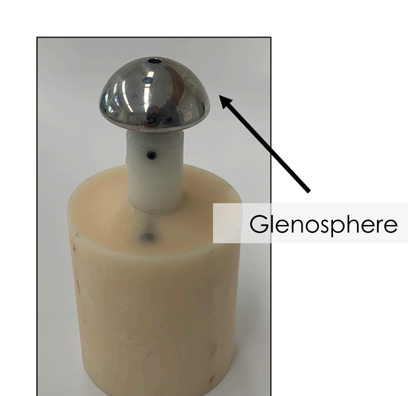

## Implanted Components

Standard Global Unite Reverse for Fracture implants were supplied by DePuy International Limited and used in this experiment. Matched humeral pairs were implanted with similar stem sizes. To avoid reaching the porous coating, a 1cm ball of PMMA in doughy state was spread around the stem approximately 3cm from the coating's edge.



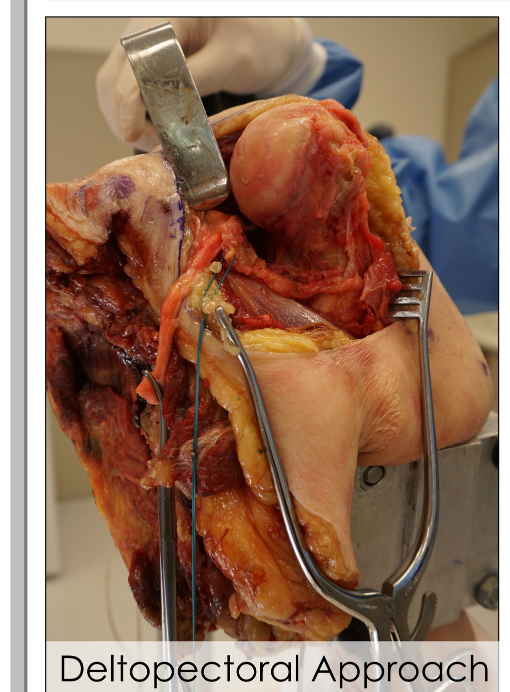


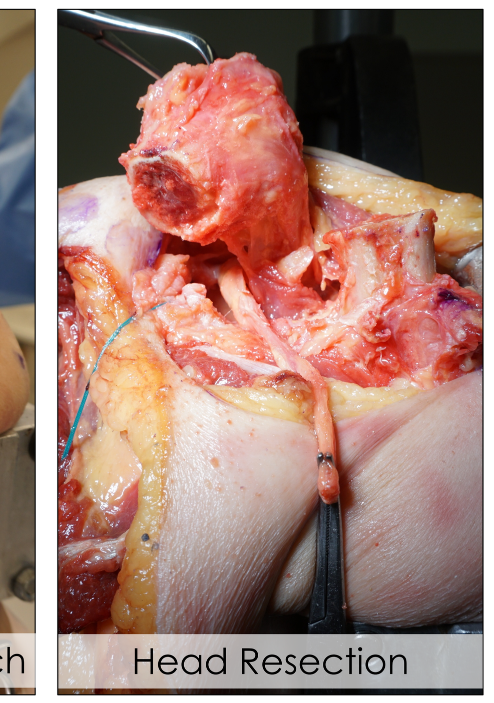
The glenosphere component that attaches to the scapula was cemented in PMMA with vertical clearance to allow for the intended range of motion.

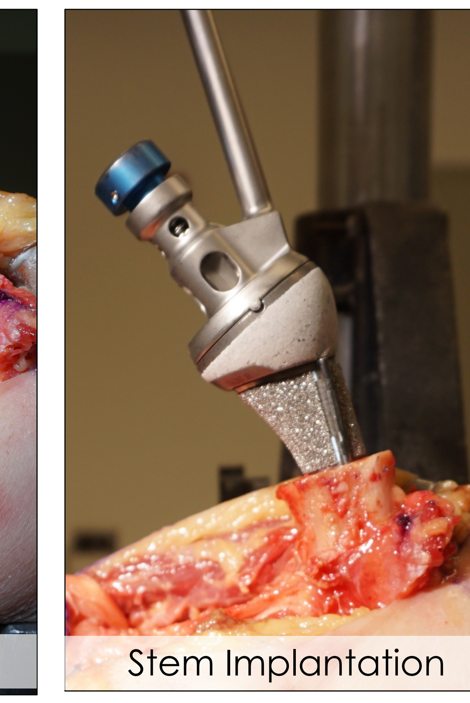



# Results

## Dissection Outcome



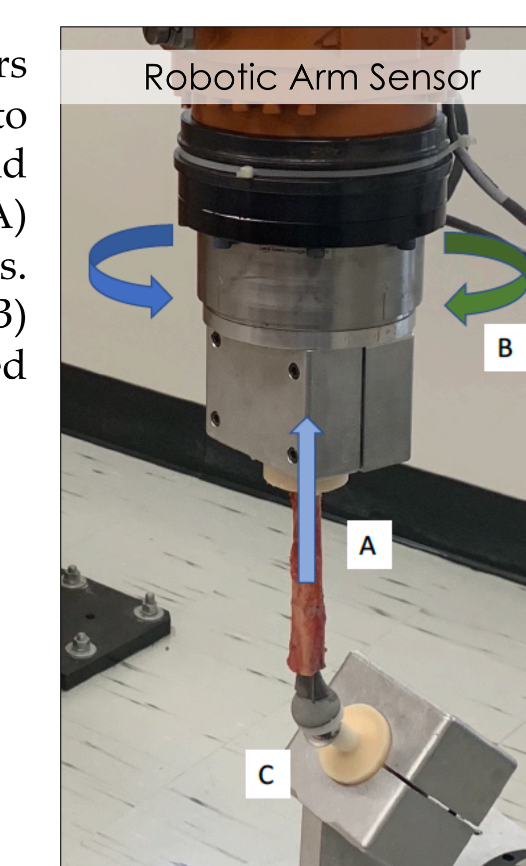

## Prepared Specimens

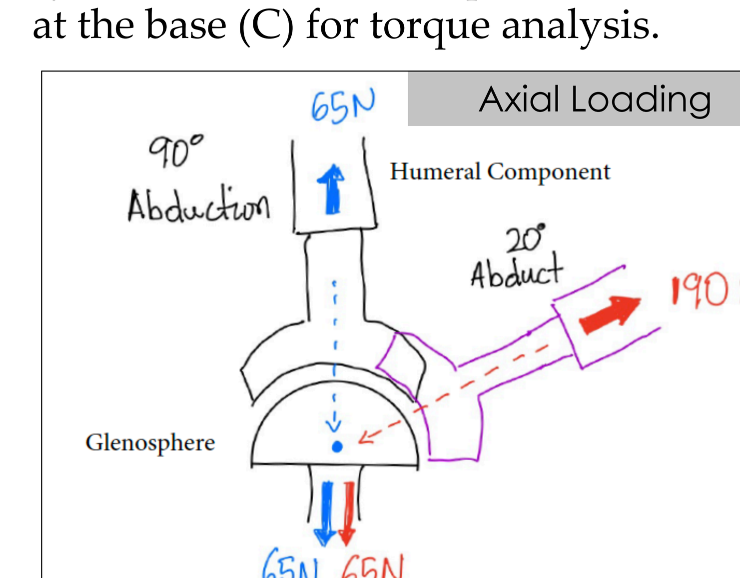

Five cadaveric specimens have been potted in PMMA from three donors ranging in age from 78-98 years of age. Most of the soft tissue was removed from the humerus.

15cm of humerus is exposed above the PMMA cylinder to minimize bone/cement interactions during testing.


## Discussion and Follow-on Tests

Our experimental analysis calls for 6 pairs of humeri for a total of 12 specimen to analyze the difference in subsidence and torque. The KUKA sensor will record (A) displacement along the humeral axis. Removal torque will be applied via (B) cyclic motion. The sample will be clamped at the base (C) for torque analysis.




We expect the experimental sample subsidence (A) to remain below the critical **5mm** discussed by Durchhiolz et al. and we expect removal torque to remain well below the **17.5 Nm** described by Gorman II et al.

*See abstract for references