



# **Testing of Shoulder-Endoprotheses**

## **Biomechanics and Wear Analysis**

Dr. Christian Abicht

- The biomechanical test of wear of shoulder implants is a suitable method for evaluation of mechanical properties of the tested implants. Testing will be performed likewise hip and knee implants under nearly physiological conditions.
- Wear testing of shoulder implants is not international standardized.
- Questmed **Accreditation** according ISO 17025 and 93/42/EEC for testing wear and strength of shoulder endoprostheses.



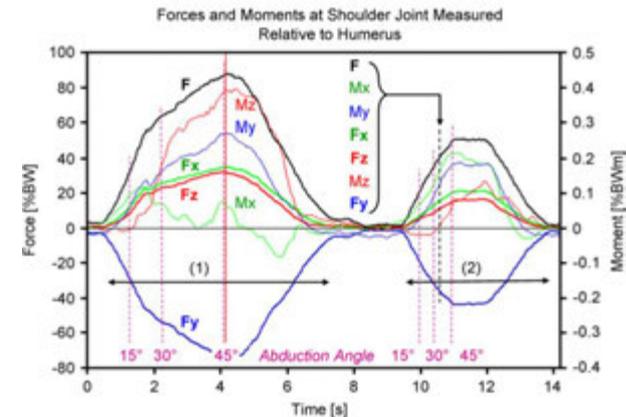
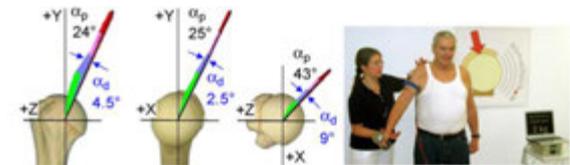
Pictures from  
[www.zimmer-bewegt.de](http://www.zimmer-bewegt.de)

- typical motion pattern were analysed
- most commonly used motions stressing the shoulder joint in the same direction.

- small change of force vector angle (abduction of  $45^\circ$  with 2 kg only 9 deg)

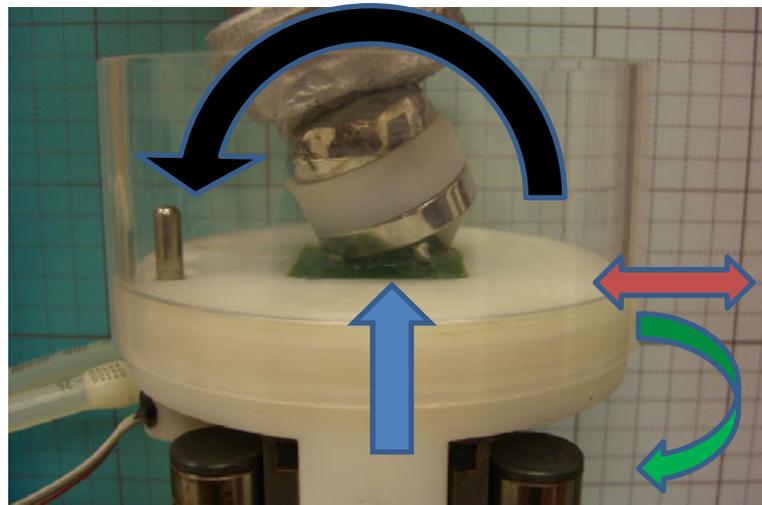
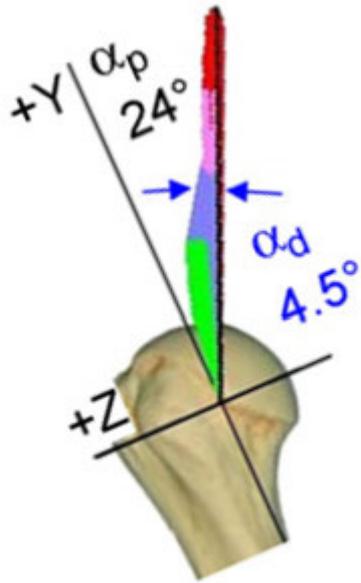
Bergmann et al 2007;

orthoload S1R\_251105\_1\_74)



# Test setup - Axis

- Force direction = **Axial force**



- Flexion due by **Translation**

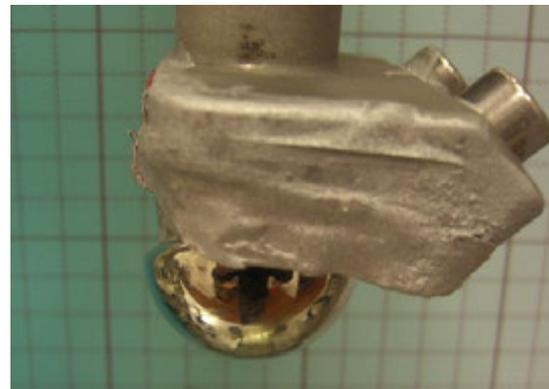


# Test setup

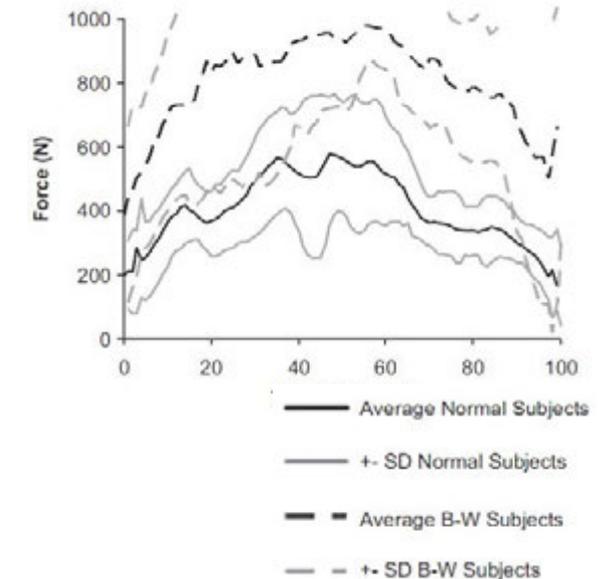
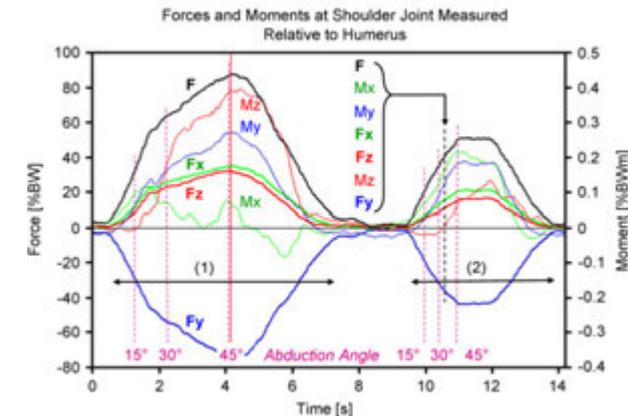
- Test medium bovine Serum
- Temperature 37°C



- Implant embedding
- According IFU



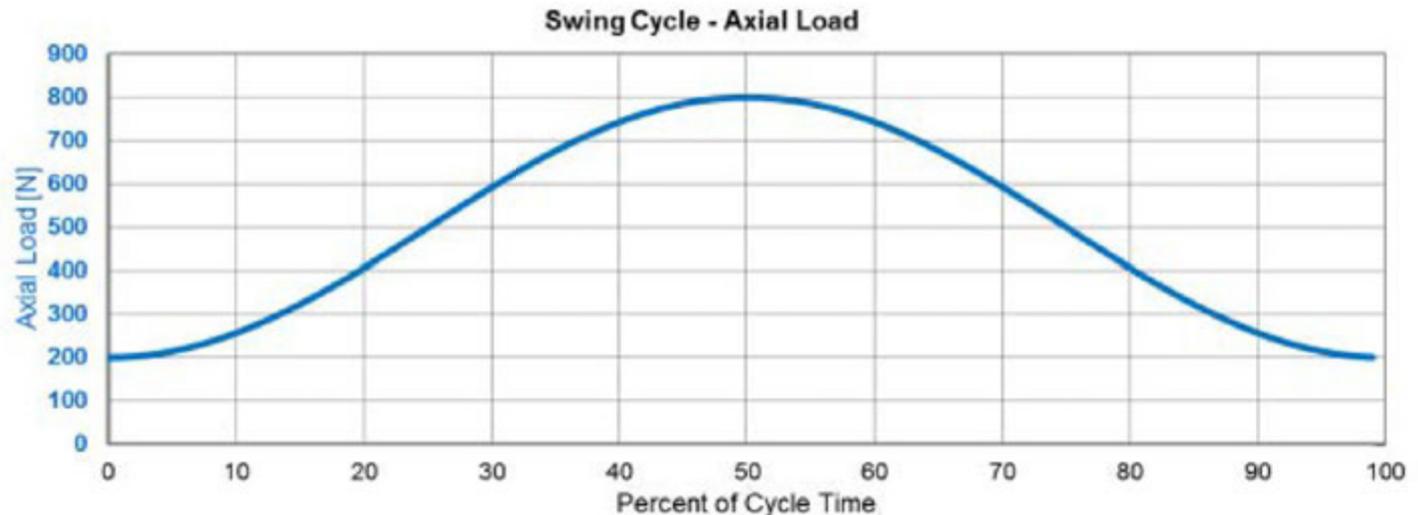
- resulting force with compression force due to rotator cuff
- abduction 2 kg: Bergmann et al 2007 orthoload S1R\_251105\_1\_74, force 850 N part 1 (part 2 without external load)
- lift shopping bag 2kg: Masjedi Johnson 2010 reversed anatomy Bayley–Walker (B–W) prosthesis during everyday activities



# Loading curves – Resulting Force

- 2 kg side lifts
- Masjedi Johnson 2010 (200N - 600N)
- Wirth et al 2009 (constant 750 N)
- Bergmann et al 2007 ( max. 850 N)
- Oosterom Bersee 2004 (constant 725 N)

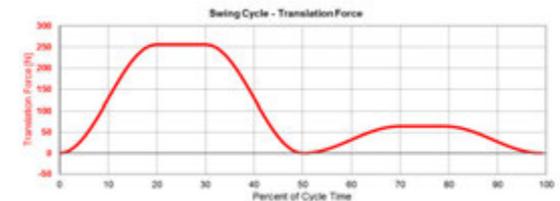
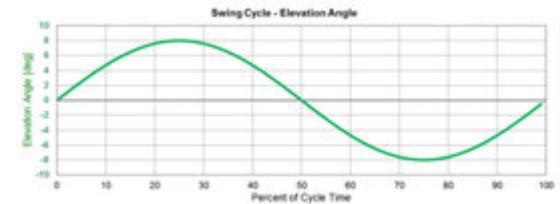
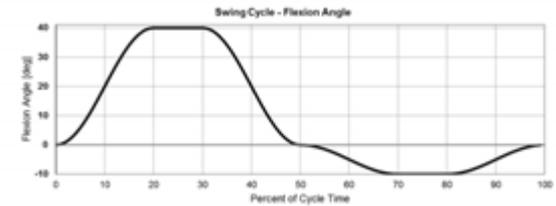
- Max 800 N
- Min 200 N



# Loading curves – Flexion, Elevation, Translation



- Motion- und Force Curves
- standard wear test
- abduction 50 degree
- elevation 16 degree
- resulting force 0 bis 256 N (translation distal)
- wear testing of Shoulder Arthroplasty anatomical and invers



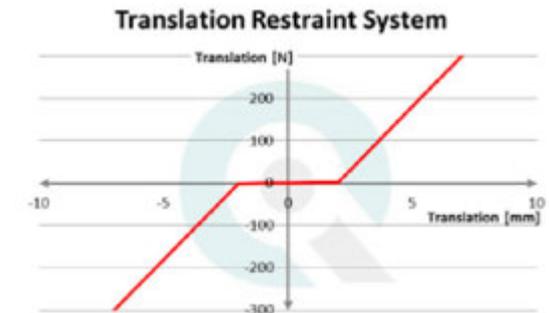
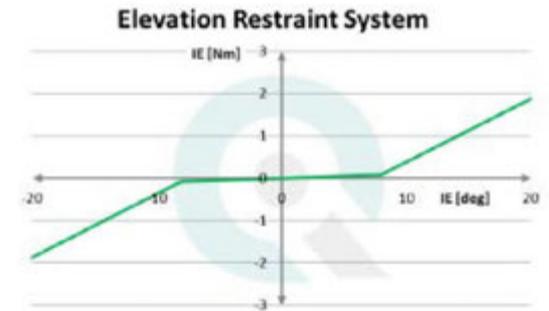
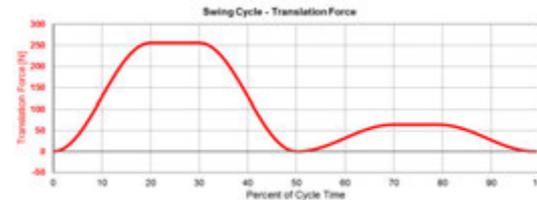
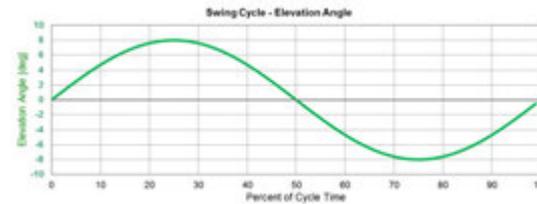
# Ligament model

- Ligament restraint system

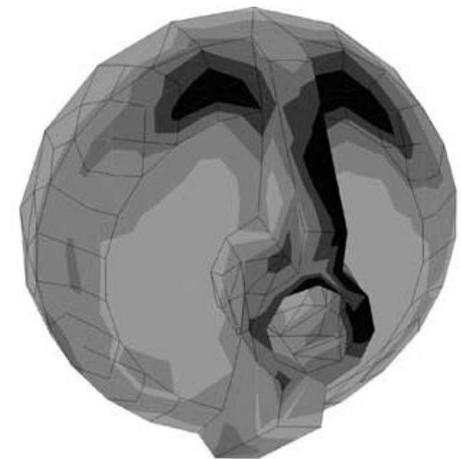
- Elevation  
0.15Nm/deg  
+/- 8 deg = 0 Nm

- Translation  
60 N/mm  
+/- 2 mm = 0 N

- four-axis force-controlled wear testing system (AMTI) with free programmable splines



- testing for 5 Mio. cycles
  - typical wear pattern at rim
  - inverse prostheses
- 
- Gupta et al 2004 FEM 60° Abduction

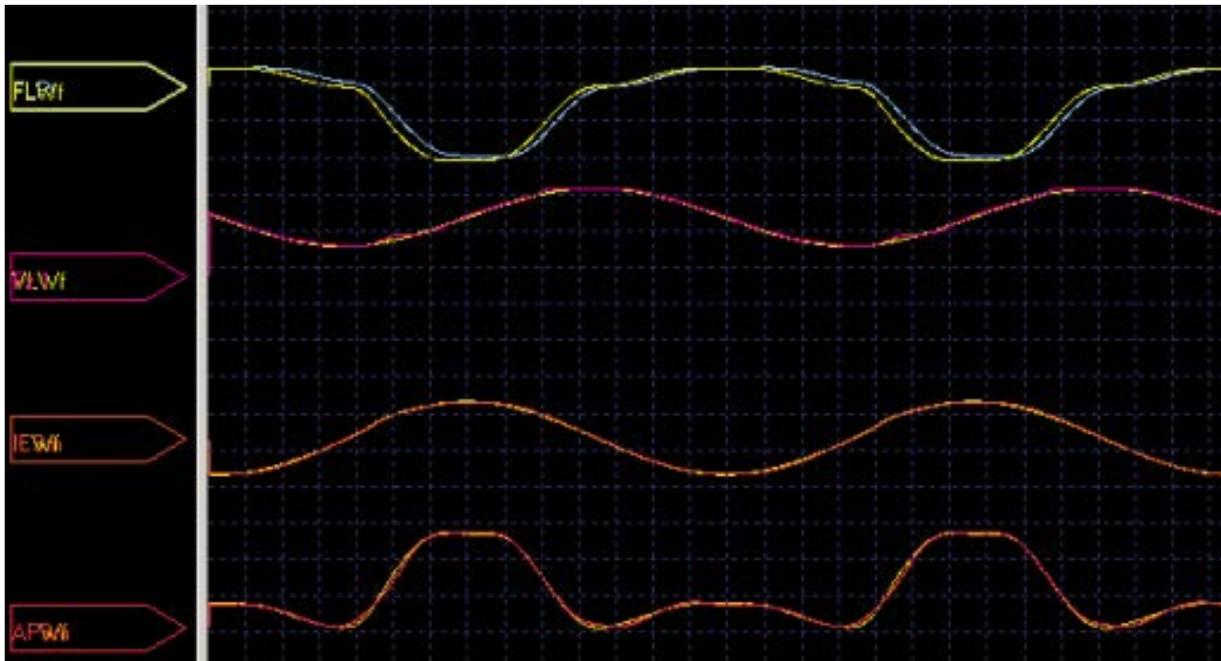


- Impingement / Notching
- complex motion

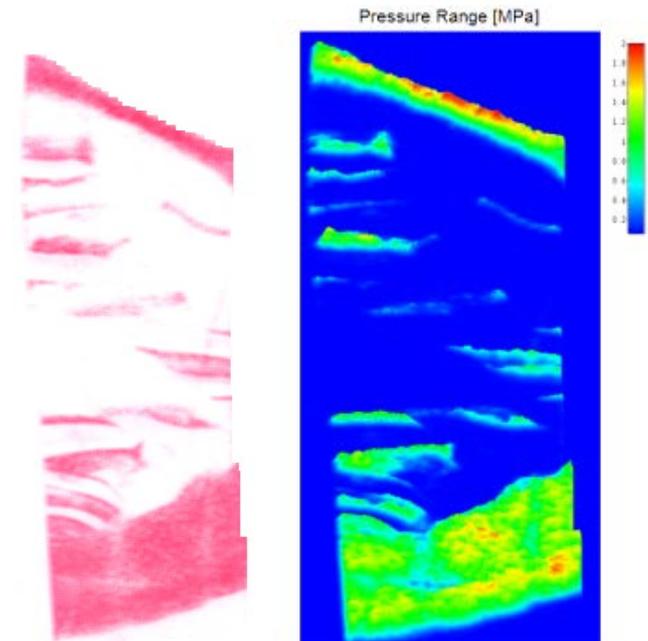


# Testing- closed-loop control

- force and angle in closed-loop control
- test setup in accordance to knee wear test



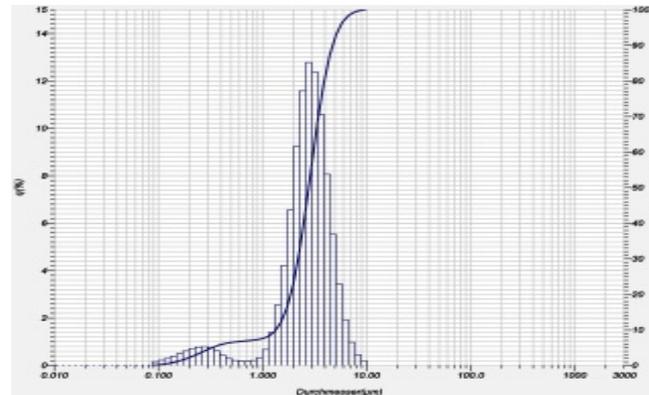
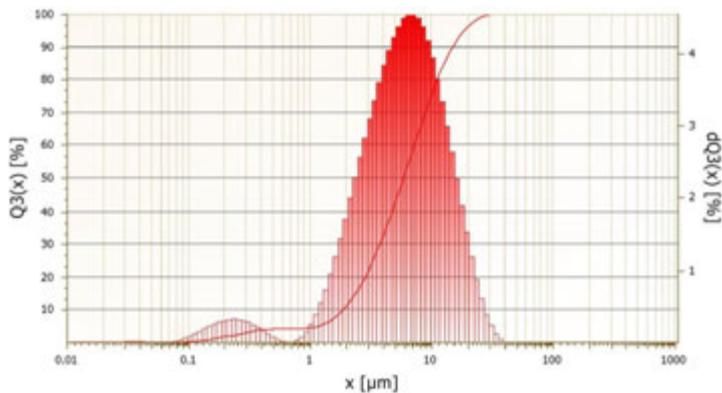
- Contact Pressure Measurement with pressure sensitive film
- Mapping Software DMFview 1.0 (© Questmed GmbH).



Original

Analysis

- during testing (also without test stop)
- only some milliliter of test serum necessary
- 0,08 $\mu$ m to 10 $\mu$ m
- partikel size histogram



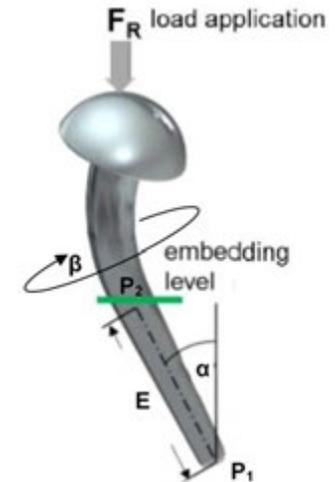
# Fatigue testing

We also testing shoulder implants according the following standards:

- ASTM F1378 - Wear, ROM,
- ASTM F1829 – Glenoid Shear
- ASTM F2028 – Glenoid

- Fatigue testing parameters

Sample size	6
E [mm]	customized Resectionline
tolerance of E	$\pm 2$ mm
$\alpha$ [°] inclination	30
$\beta$ [°] rotation	45
tolerance of $\alpha$ and $\beta$	$\pm 1$
Load $F_R$ [N]	2400
$N_D$ [Cycles]	1.000.000
f [Hz]	5
Test medium	Air 23°C, Saline 37 °C



- wear testing of Total Shoulder Arthroplasty (TSA) with physiological loads
- fatigue testing of Total Shoulder Arthroplasty (TSA) with physiological loads
- other loads (biomechanics) free to testing

Dr. rer. med. Dipl.-Ing. Christian Abicht

Questmed GmbH, Albert-Einstein-Ring 9, 14532 Kleinmachnow