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# Analysis of Neck Sparing (TSI) Versus Conventional Cementless Stem

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# Disclosures

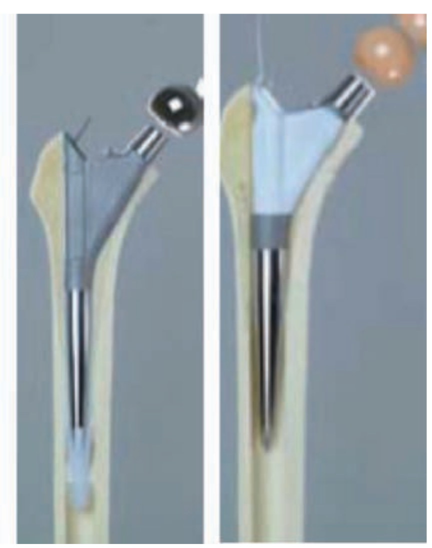
## Timothy McTighe, *Declan Brazil

- Held Shares in CDD, LLC, Omnilife Science, J&J, Zimmer
- Received Royalties from: CDD, LLC, Omnilife Science, GOT
- Done consulting work for: Omnilife Science
- Received institutional support from 1971: +30 companies.
- Equity Position: *Signature Orthopaedics

# Design Rationale

- **Reduce the stresses generated in “modular” short stem.**
- **Compare resulting short stem stresses to conventional stem when restoring same head centre.**

**Pipino advocated the use of short curved neck sparing stem. CFP™ Titanium stem design 1996**

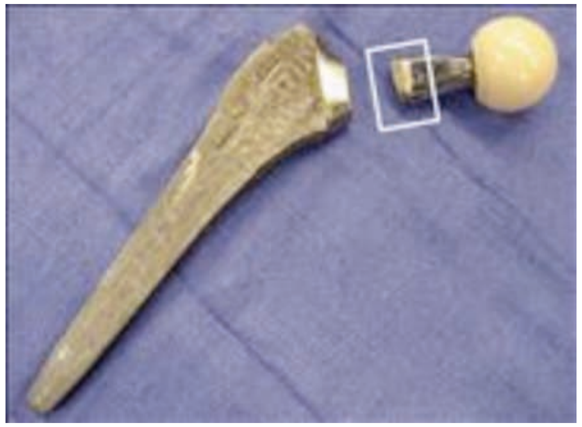


**Freeman advocated Neck conserving since 1980’s**

**Design Principles**

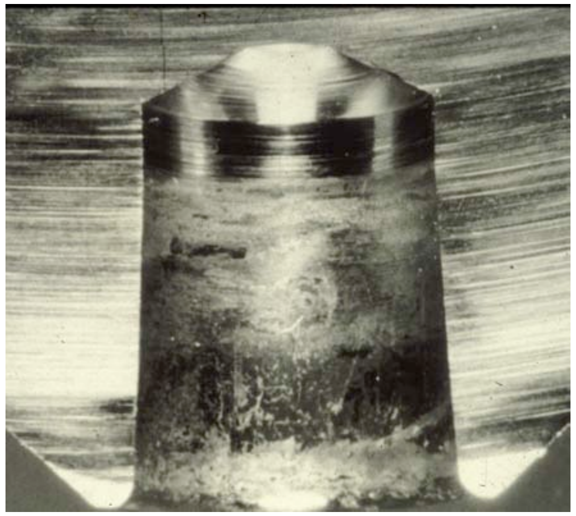
# Design Inputs - Modular Stem problems

- Fatigue Failure of Modular Neck - Wright Medical




- Corrosion / Metal Debris Issue

Significant Current Concern



# Current Retrieval Analysis
## Collaboration with JISRF and DARF (Donaldson & Clarke)

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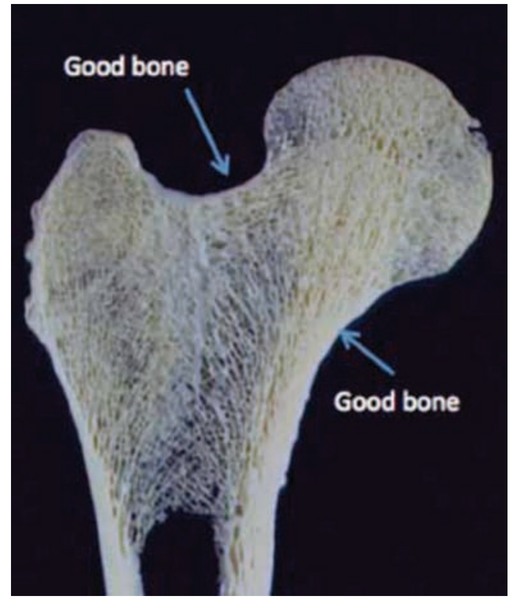
# Engineering the optimized solution...

- Fatigue Failure of Modular Neck
    - Switch Neck Material from titanium to Cobalt Chrome.
- Corrosion / Metal Debris Issue
    - Complex problem, many mechanisms that can contribute.
    - NPL Publication defines over 12 types of corrosion
    - Consider the most applicable to stem/neck design
        - Fatigue Corrosion
        - Fretting Corrosion
        - Stress Corrosion

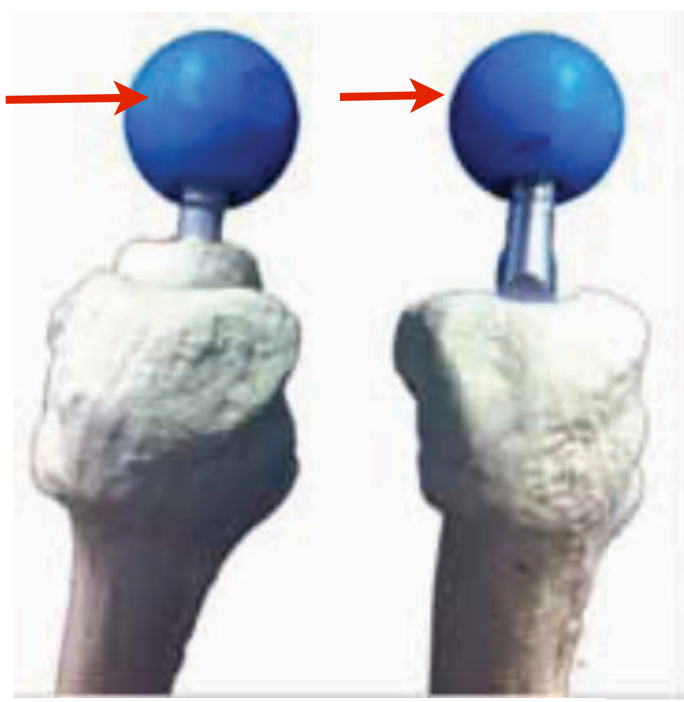
→ STRESS

# Stress Reduction through anatomy

## Use anatomical structure to reduce Stresses in stem.

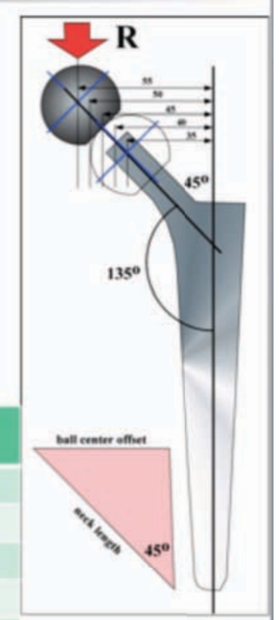



### Reduce Torsional Moment

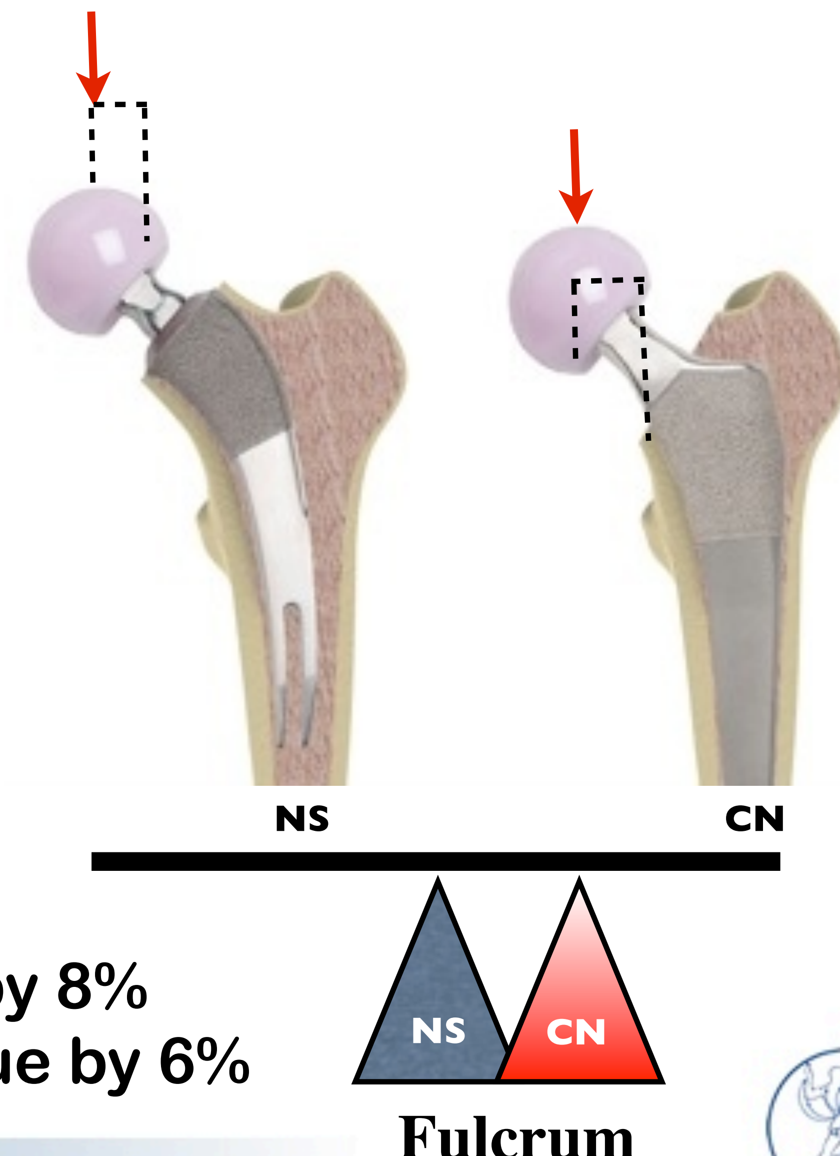


•8% per 1mm increase in true lateral ball-center offset
•6% per 1mm increase with the ball's neck-length size adjustment.

| offset | Neck-length | Nm |
|---|---|---|
| 35 mm | 49.50 | 84 |
| 40 mm | 56.58 | 96 |
| 45 mm | 63.65 | 108 |
| 50 mm | 70.72 | 120 |
| 55 | 77.79 | 132 |

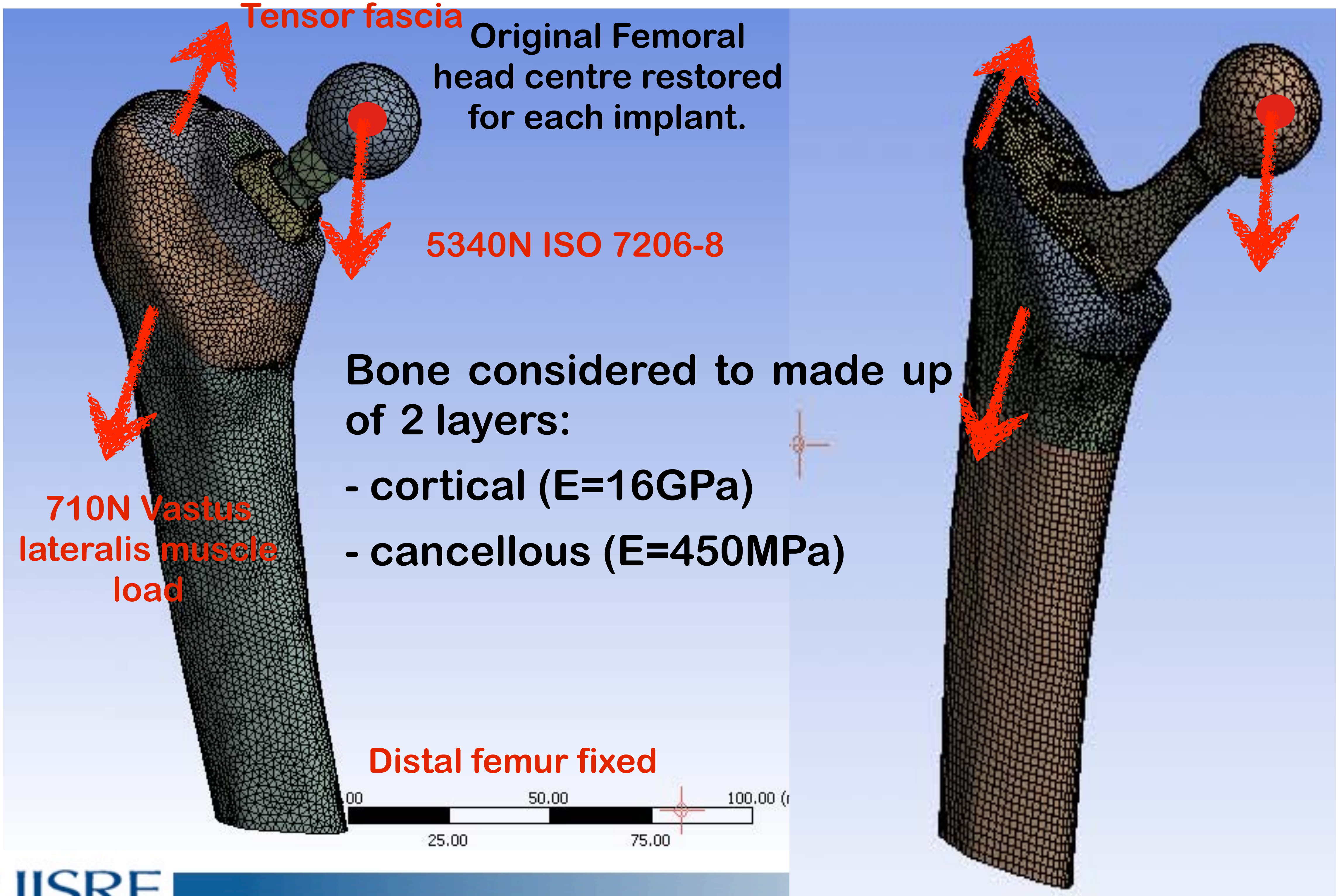



### Reduce Bending Moment




**1mm increase in femoral offset increases torque by 8%**
**1mm increase in head/neck length increases torque by 6%**

# FEA Simulation




Bone considered to made up of 2 layers:

- cortical (E=16GPa)
- cancellous (E=450MPa)

# FEA Boundary Conditions & Materials

## Components used to restore head centre

- TSI implant size 1 (range supplied is 1 through to 5), 22mm neck with +8mm head.
- Taperloc Stem Size 3, high offset with +8mm head.

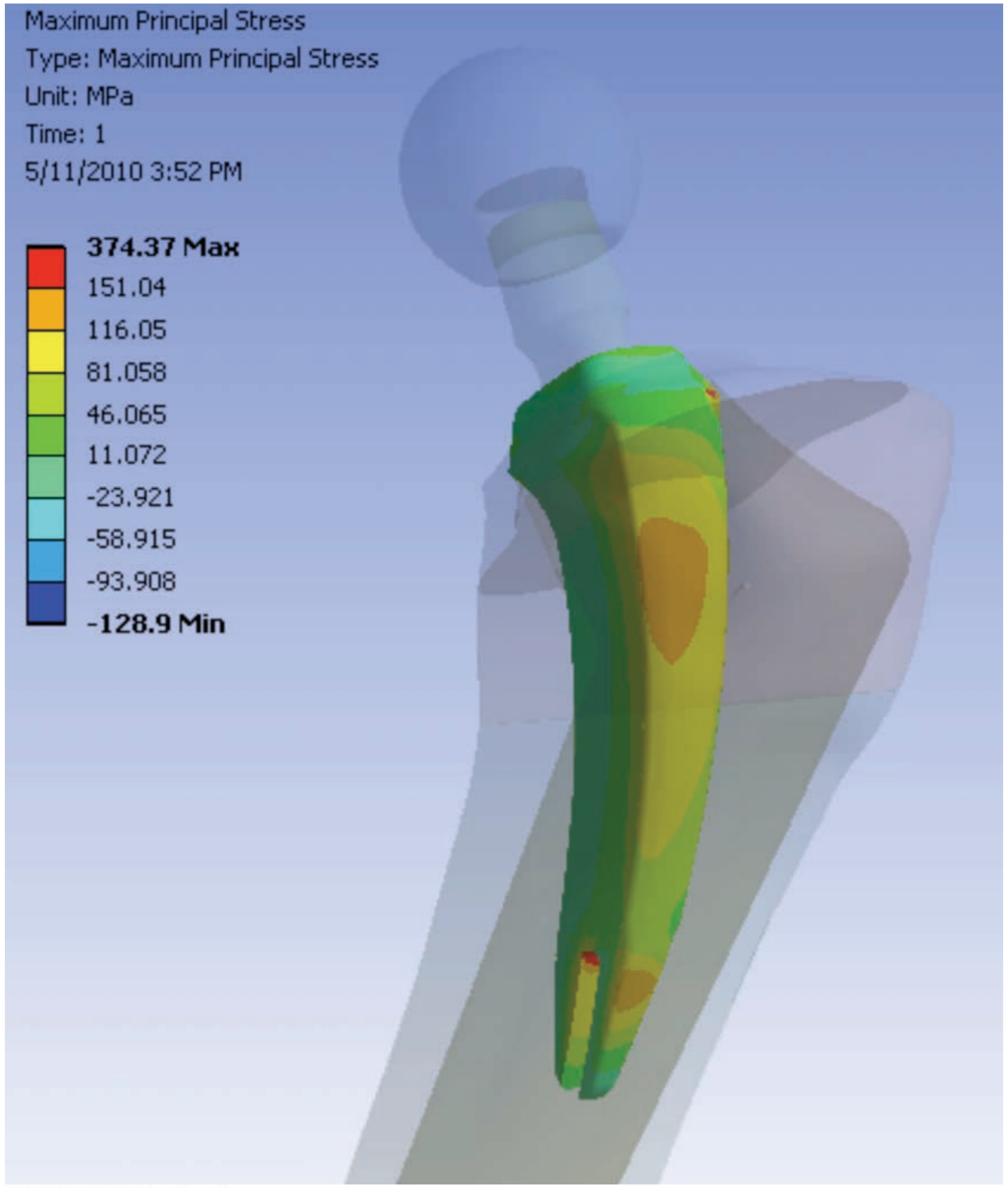
**Both Stems have Plasma coated proximal bodies and uncoated distally. Both implants were bonded to bone in coated region and frictionless conditions of remaining part of stem.**

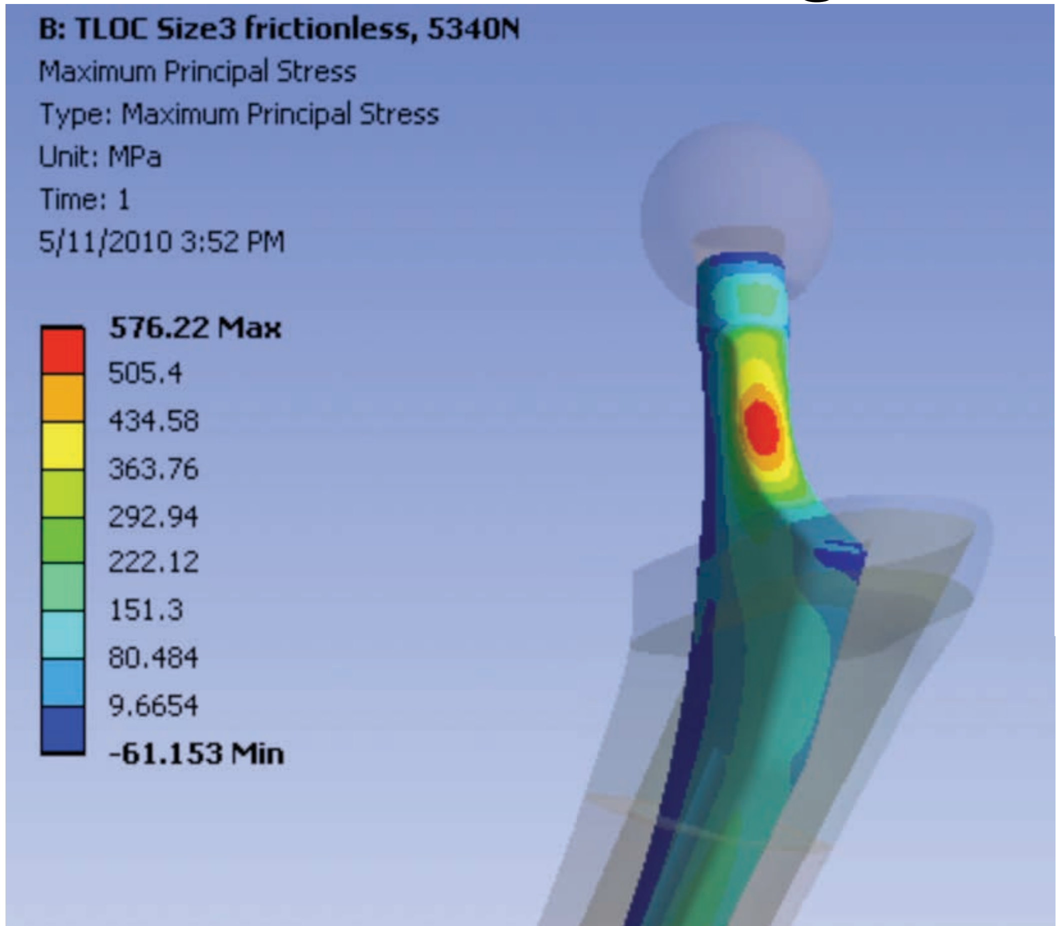
Implant Materials:

- Neck Stabilisation implant Titanium Stem, CoCr Neck.
- Conventional Stem, Monoblock Titanium

# Simulation Results

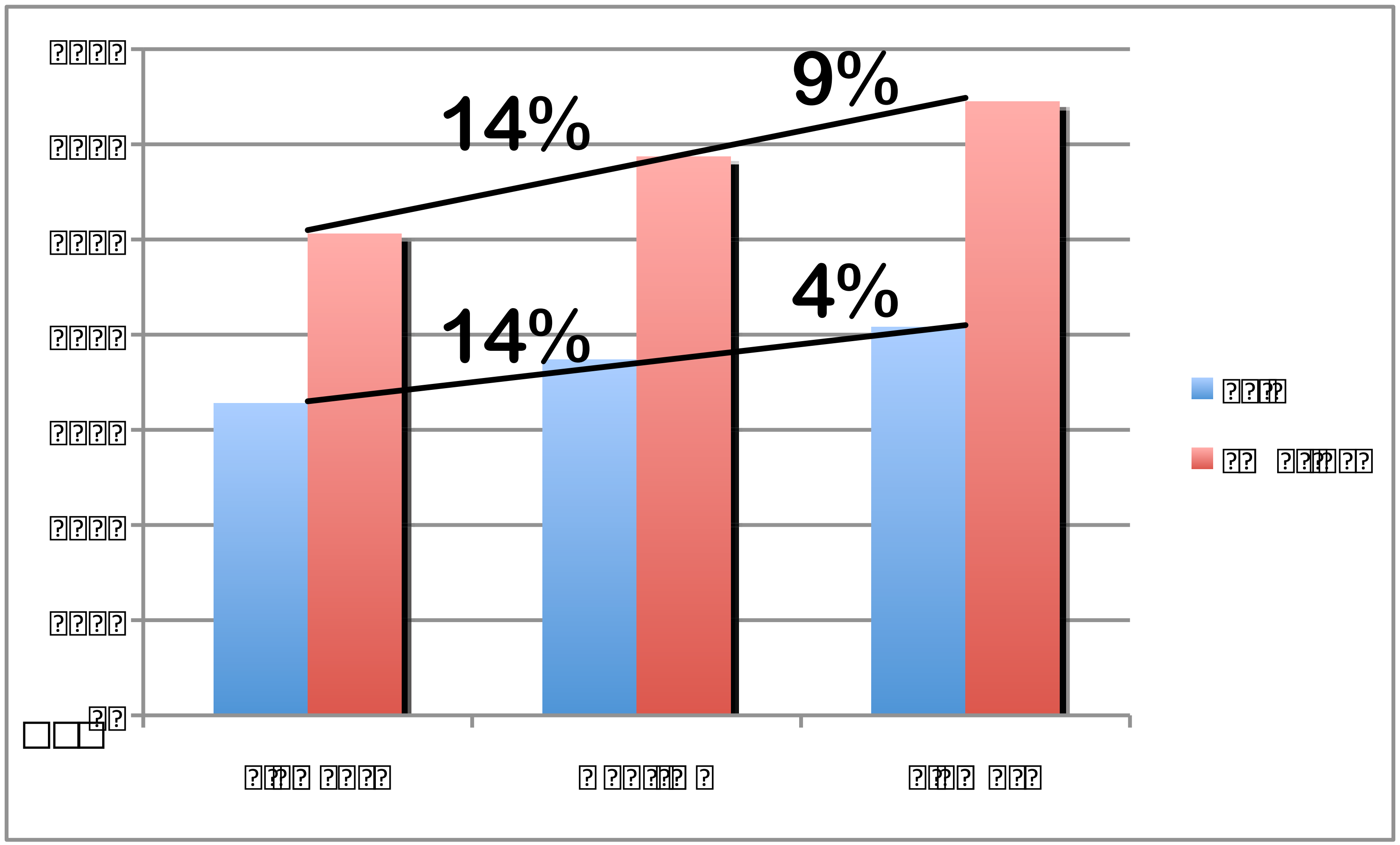
- **The maximum principal tensile stress in the neck stabilisation stem was 35% less than that of the monoblock design.**




# Effect of Varus / Valgus tilt
# Maximum tensile stress in stem

- **The effect of Varus tilting Stem was much less for the neck stabilisation stem compared to the monoblock design.**

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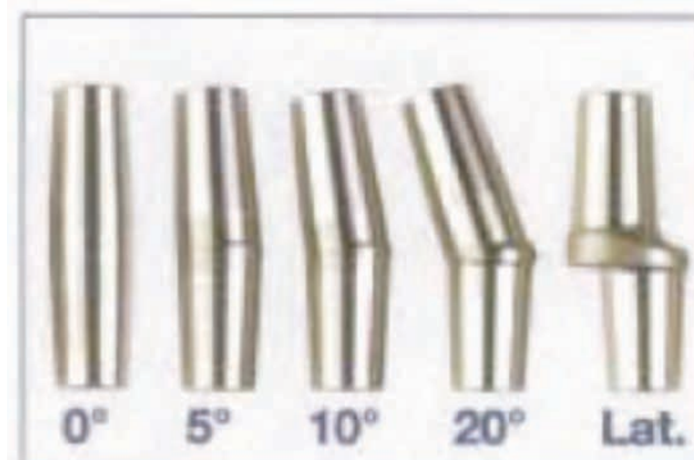
# Optimal Taper Design

- **Stresses lower due to neck sparing design.**
- **Further Stress Reduction by Taper Design (Not all tapers are equal)**
  - **Cremascoli Geometry Design.**

**Rectangular geometry is torsionally stable and has optimal bending strength**




**Circular Taper has insufficient intrinsic stability for in-vivo torsional loads**

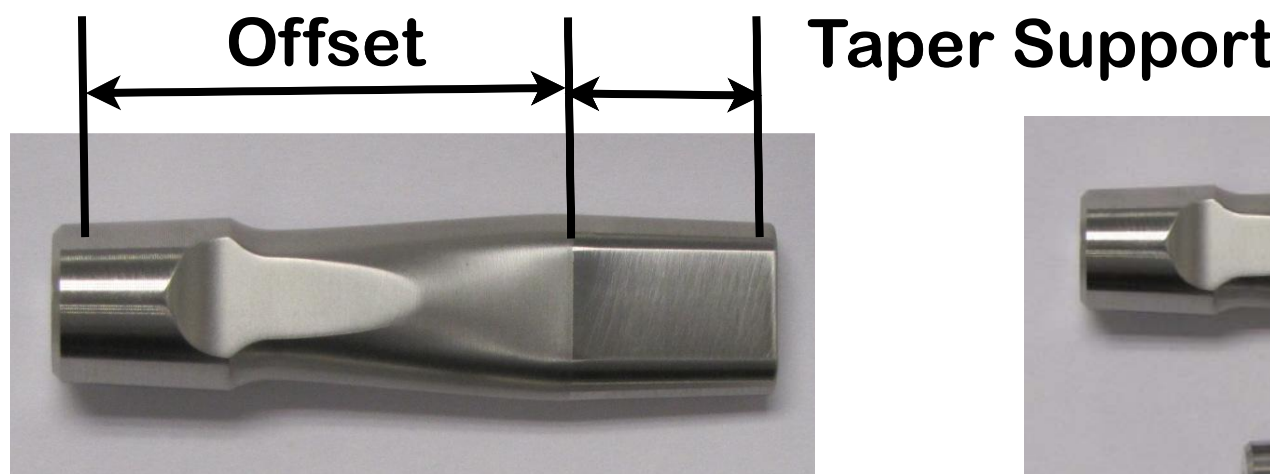
**Concern**

**Short Taper ratio**

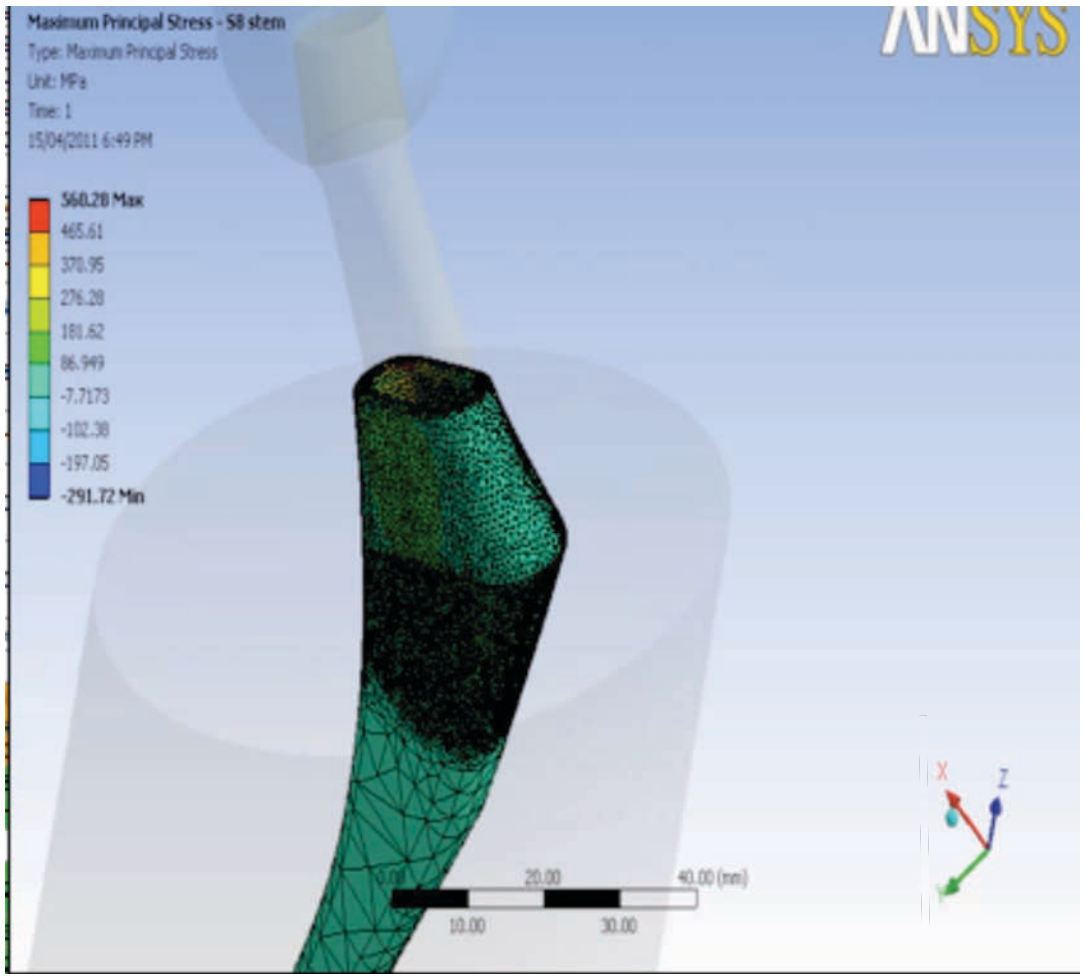
**Shot Peening**

# Optimal Taper Design through Neck Stabilization

| | Taper Support | Offset | % Increase head centre length |
|---|---|---|---|
| TSI (ARC) | 17 | 27.5 | |
| Wright Medical | 15 | 42 | 55% |
| Stryker | 13 | 42 | 53% |

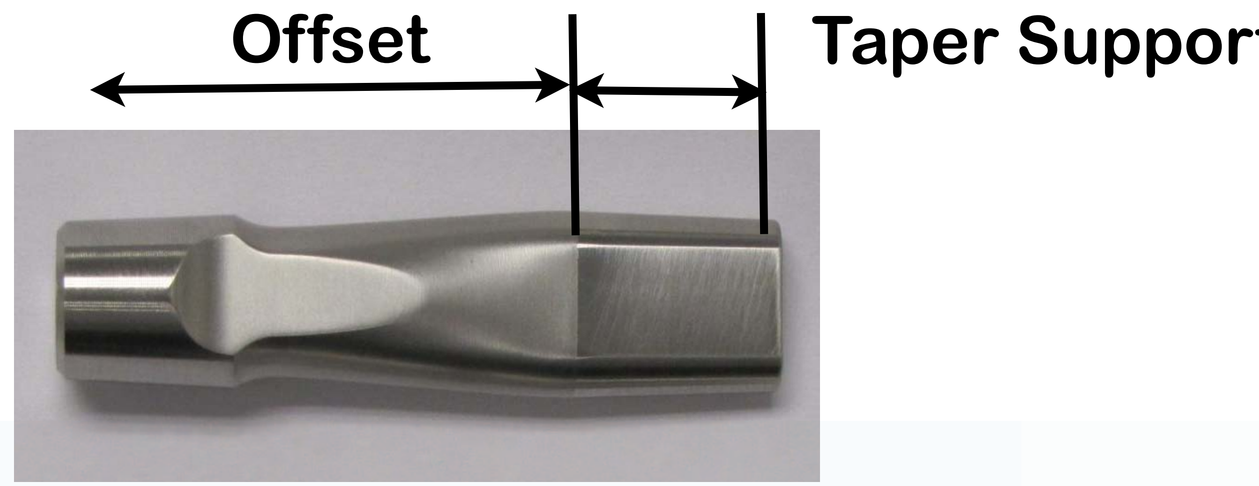


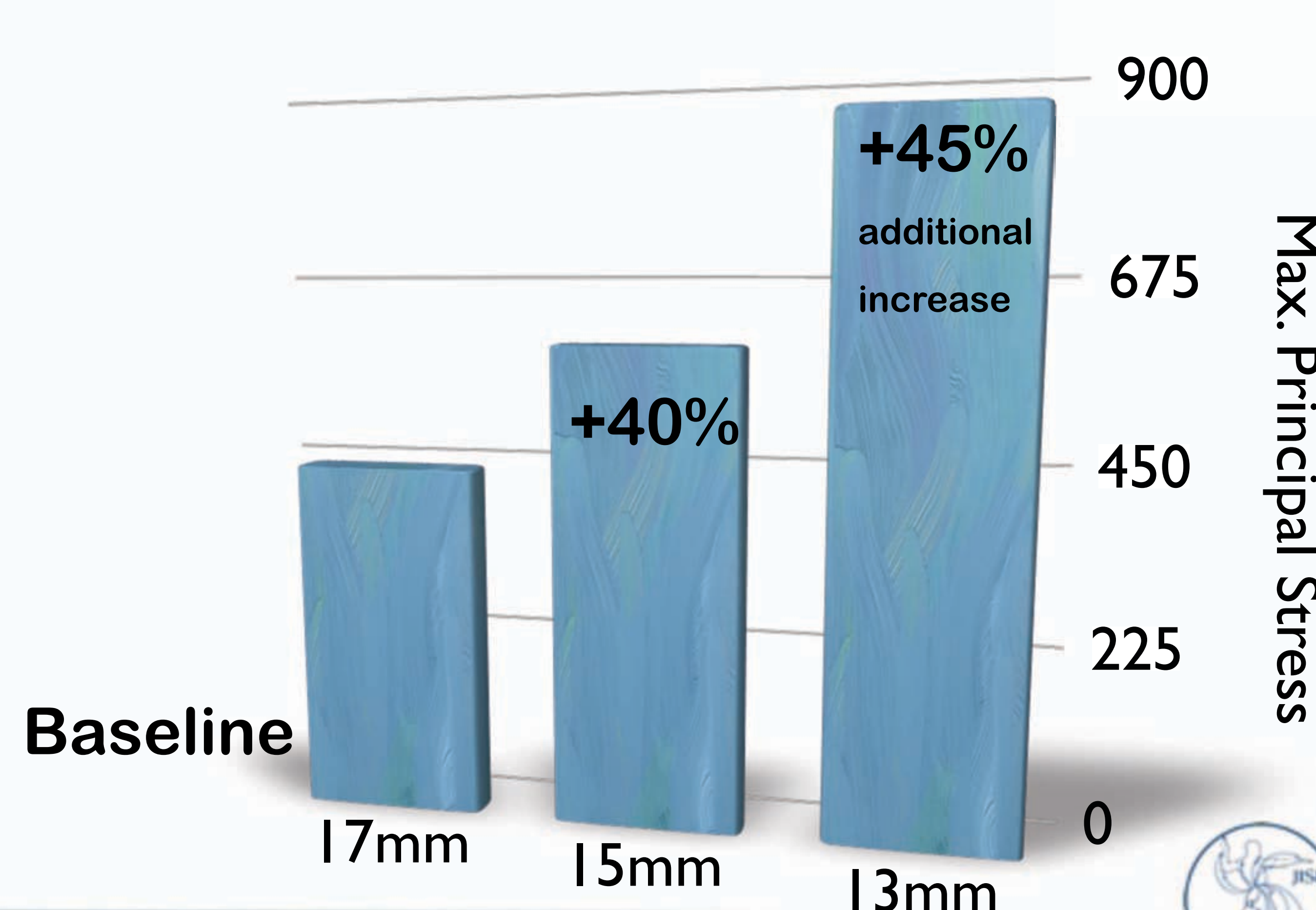

# Optimal Taper Design through Neck Stabilization




**Analysis performed with Fixed Offset, Fixed load & Boundary Conditions.**

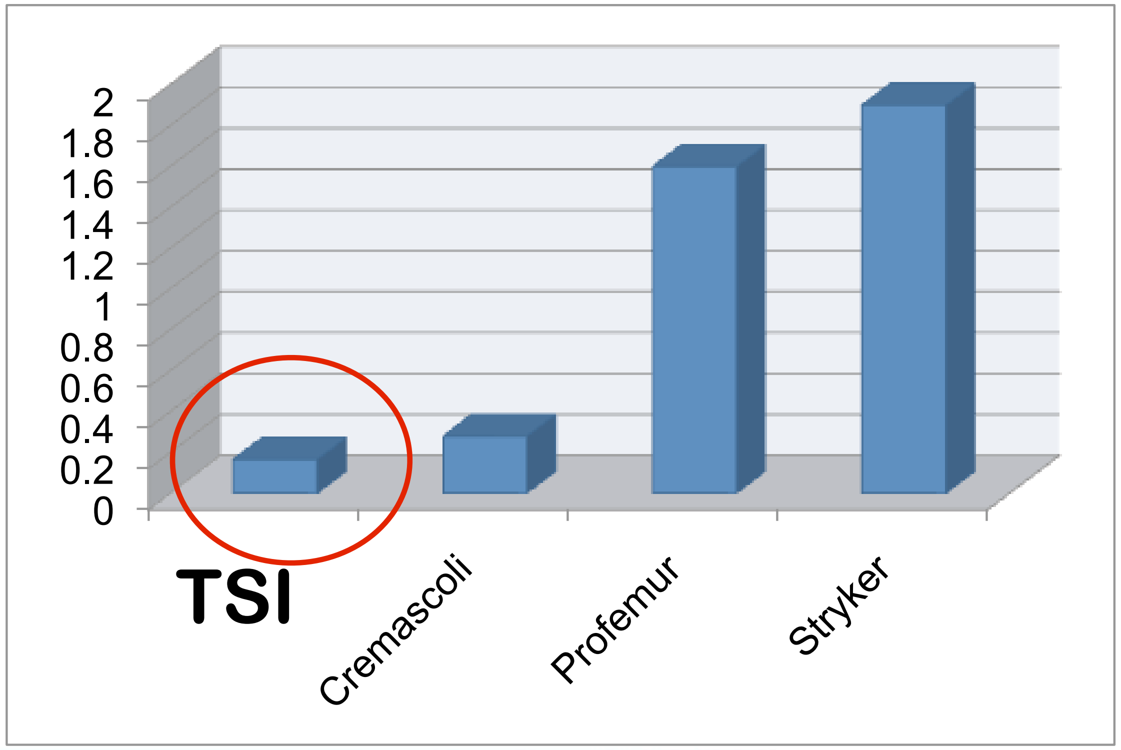
**Design Variable Taper Support length**



# Optimal Design Conclusions

- Biomechanical advantage of neck stabilization stem produces lower stress in stem compared to monoblock equivalent (for identical head centre restoration)
- Stress variation due to prosthesis tilting on monoblock design has more effect than neck sparing neck.
- Neck Sparing design enables lower stresses due to combined shorter offset with larger taper engagement, thus reducing corrosion / debris generation.




Published Data compared to Neck Sparing Design (TSI)

# Thank You

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