SE 07

# Understanding Why Dual-Taper Hips Fail

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Consulting/Royalty payment has been received directly related to products discussed

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## **D**ual-taper systems

***Advantages:*** biomechanical, mixing of materials, facilitation of revision arthroplasty [1];

***Disadvantages:*** mechanical failure [2], metal ion release [3], corrosion at the modular interface [4], bony erosion [5].

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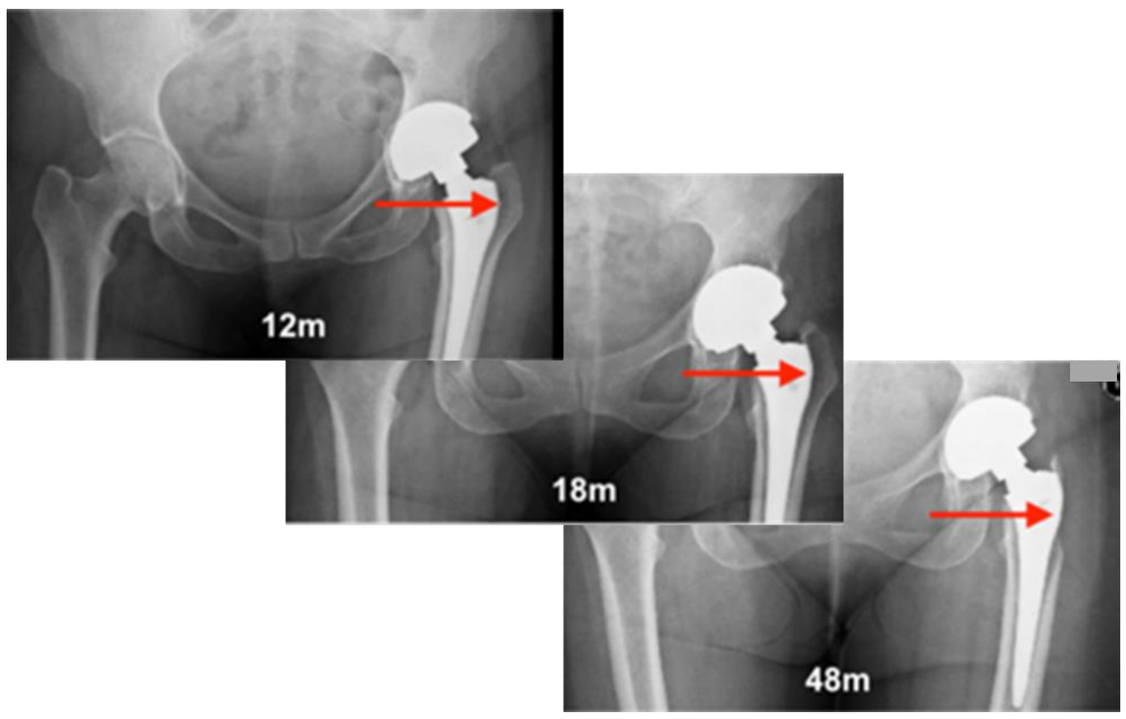
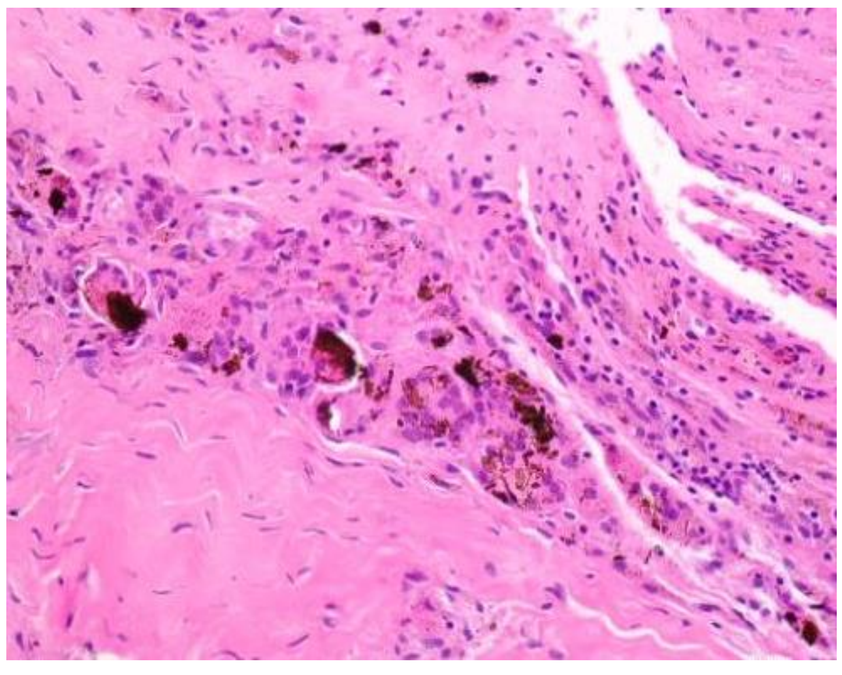
# Our Study

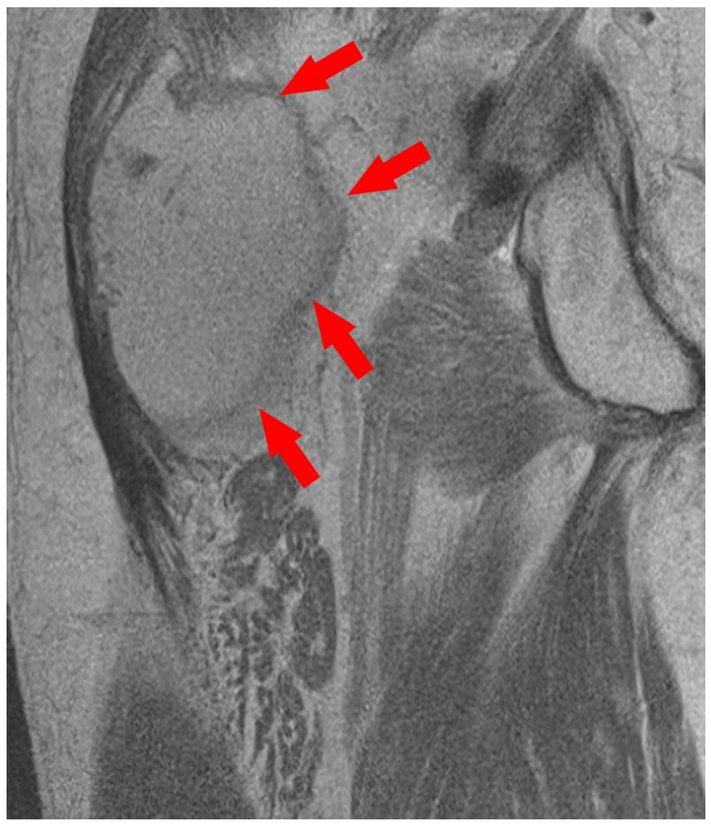
We prospectively recruited 100 patients with failed dual taper hips, collecting pre, intra and post op data to determine the clinical category of failure. Pre-revision blood metal ion levels were measured using ICPMS and, in a proportion of patients, CT was used for component position analysis and MRI was used for soft tissue analysis.




Progressive erosion of the greater trochanter (red arrows) on plain radiographs at 12, 18 and 48 months after implantation.

Histology of a specimen from the synovial bursa, greater trochanter reveals the presence of metal particles in giant cells and macrophages.





MARS MRI showing pseudotumor formation.

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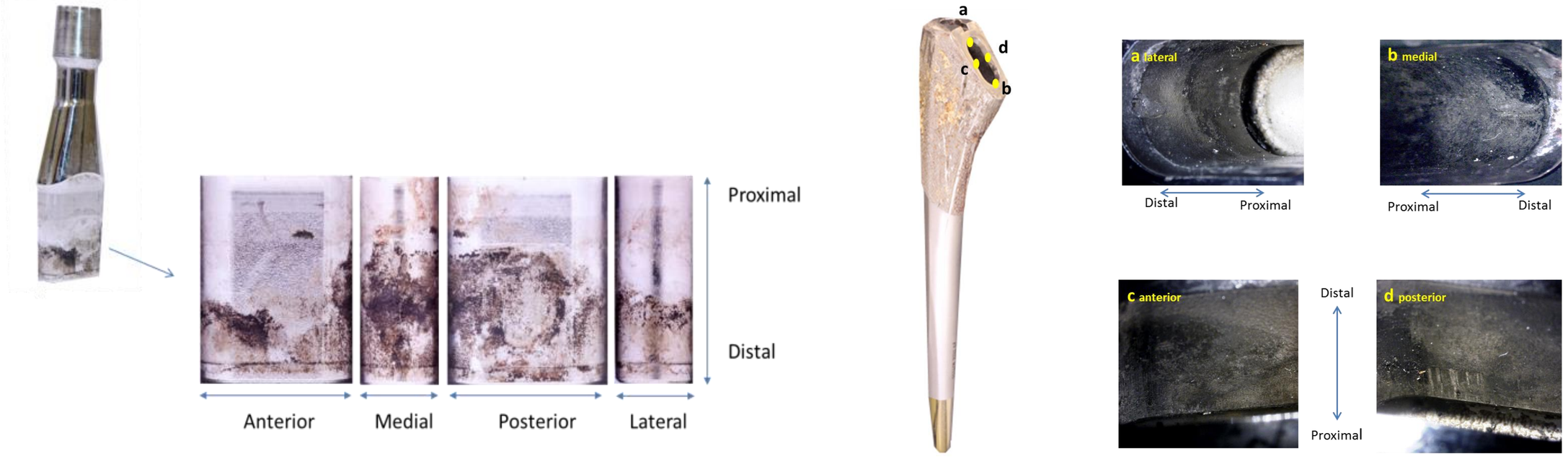
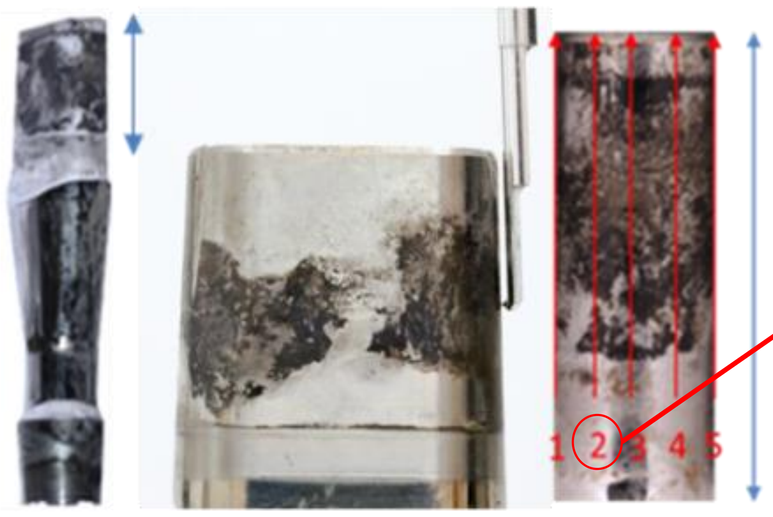
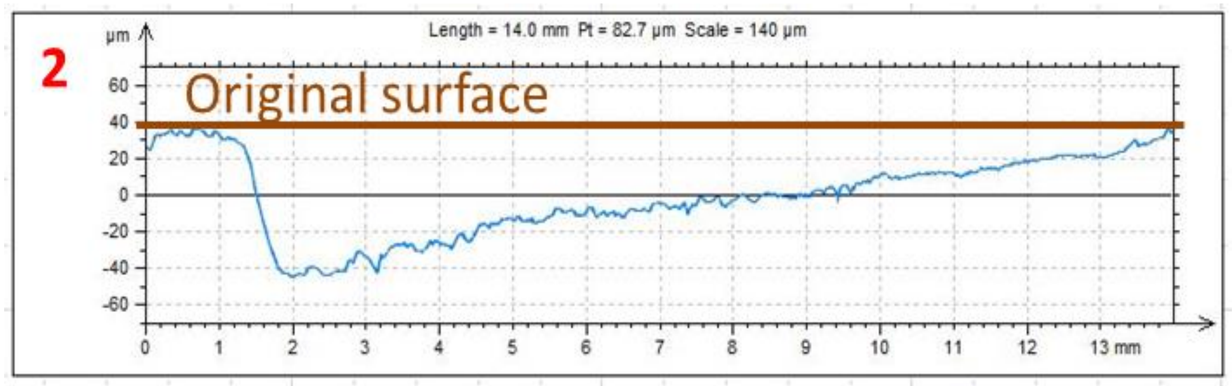
# Our Methods

Macroscopic inspection and light microscopy was performed to assess the severity of surface damage of each stem (both male and female parts) using a previously published scoring method [6].

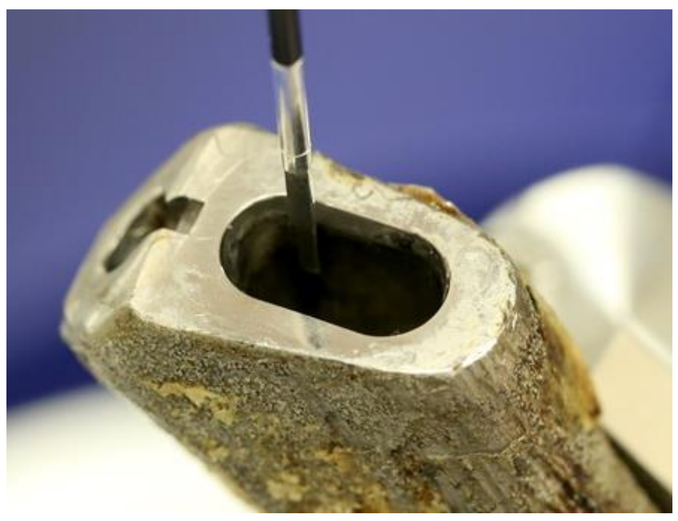


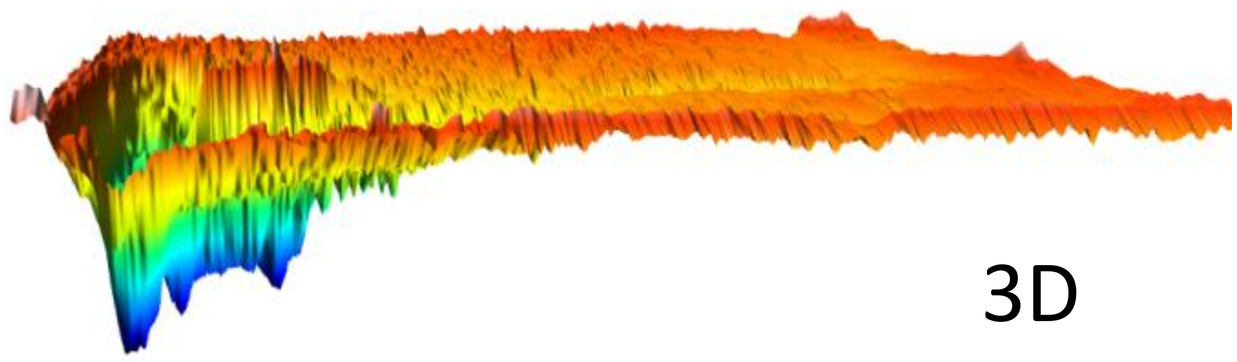

A measurement method, using a roundness measuring machine was developed to quantify the severity of the damage on round ends of the tapers. With this method five longitudinal traces were taken on each round section of the taper surface to compute the relative depth of damage.




2D





3D

These traces were normalised relative to unaffected surface of the taper and a sectional wear area was computed. Average area of these five traces provided a measure of surface damage for comparative purposes. The result obtained was normalised with time in situ.

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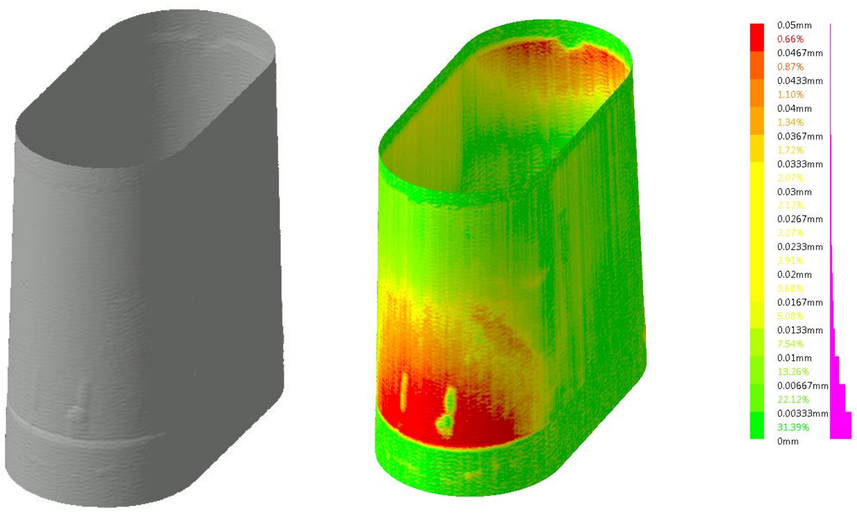
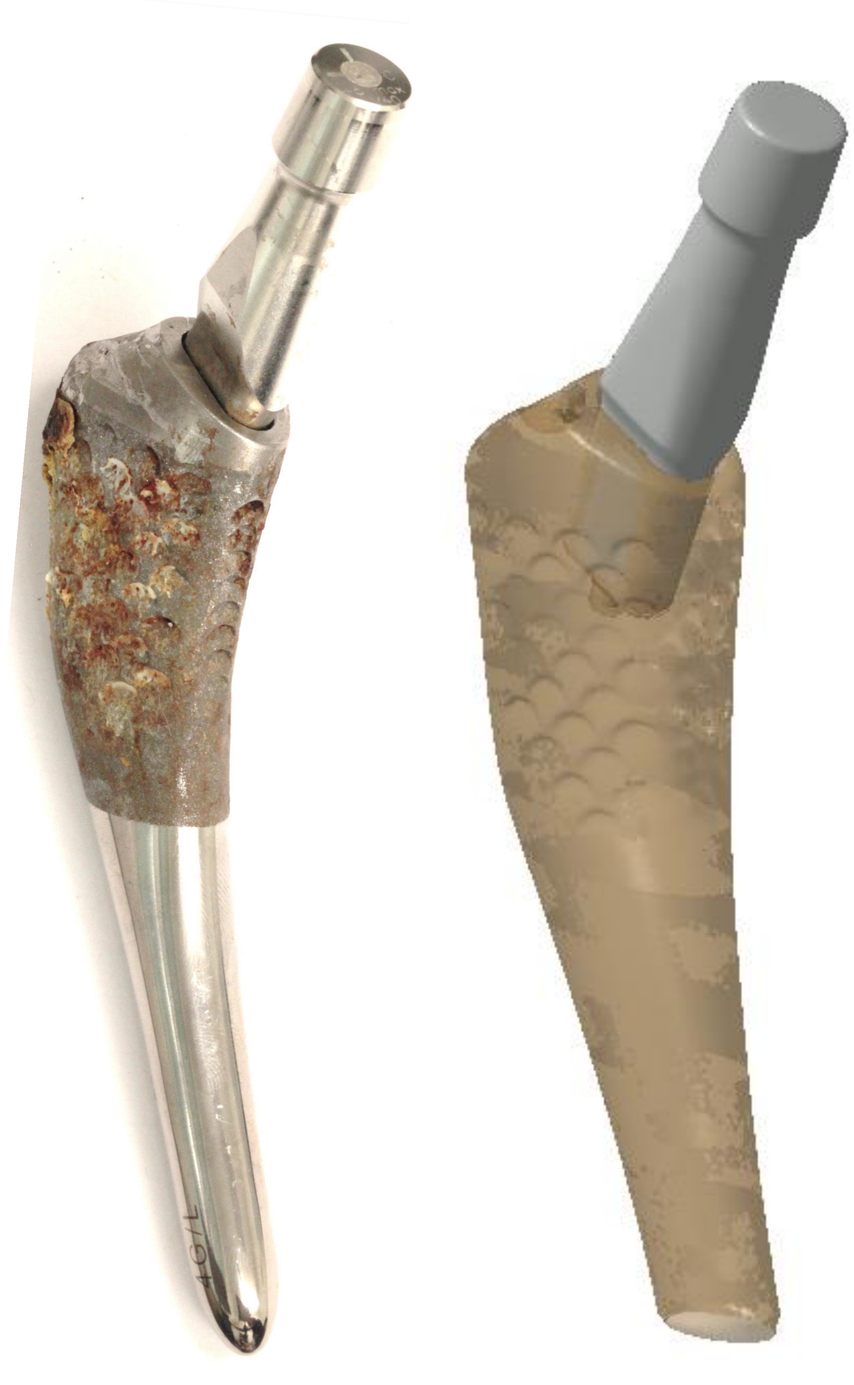
# Multi Scale Metrology Approach

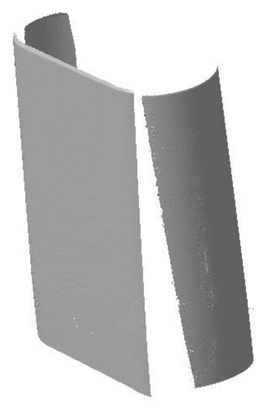
## Coordinate Measuring Machine

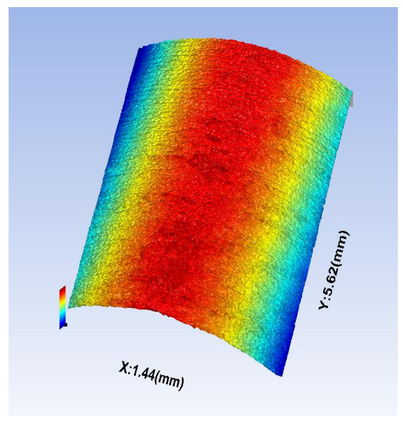



- 400 vertical scans at 0.05mm point spacing
- Reconstruction of original geometry based on iterative best fit algorithm and unworn sections
- Resolution enables estimation of overall material loss volume and linear penetration



## Optical measurements

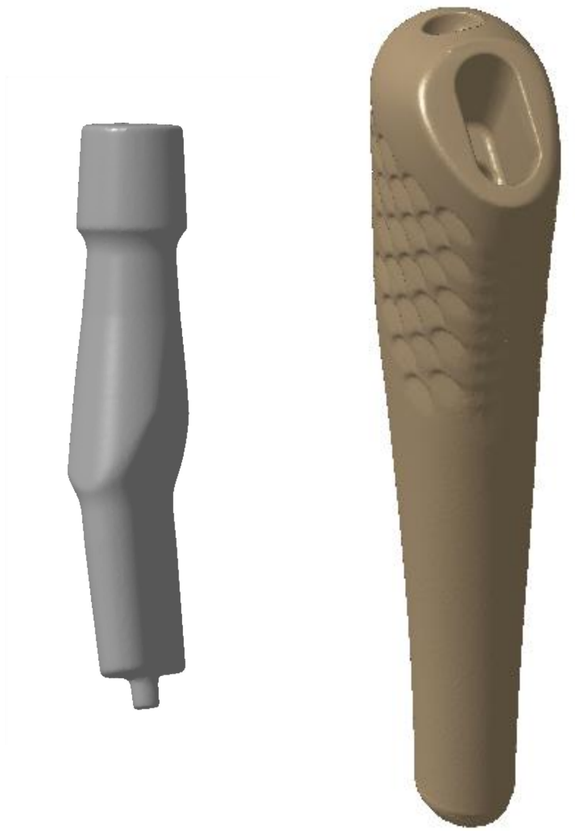





- Form, roughness measurements based on infinite focus variation
- Estimation of local material loss volume/linear penetration
- Ability to compute 2D/areal surface parameters to investigate changes in surface texture

## Computer Tomography - Industrial microCT

- 1500 slices to provide reconstruction of 3D model
- Reconstruct the virtual assembly between components
- Provides framework for data fusion of multi scale data from CMM and optical measurements



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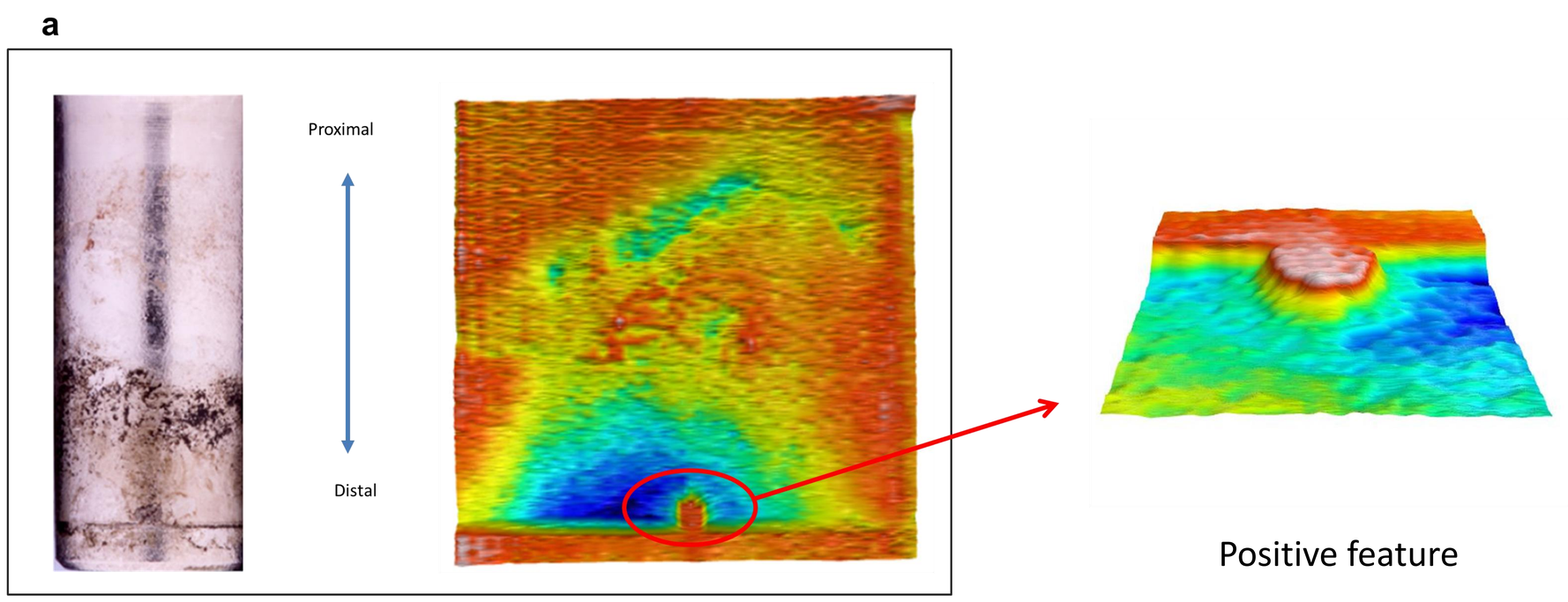
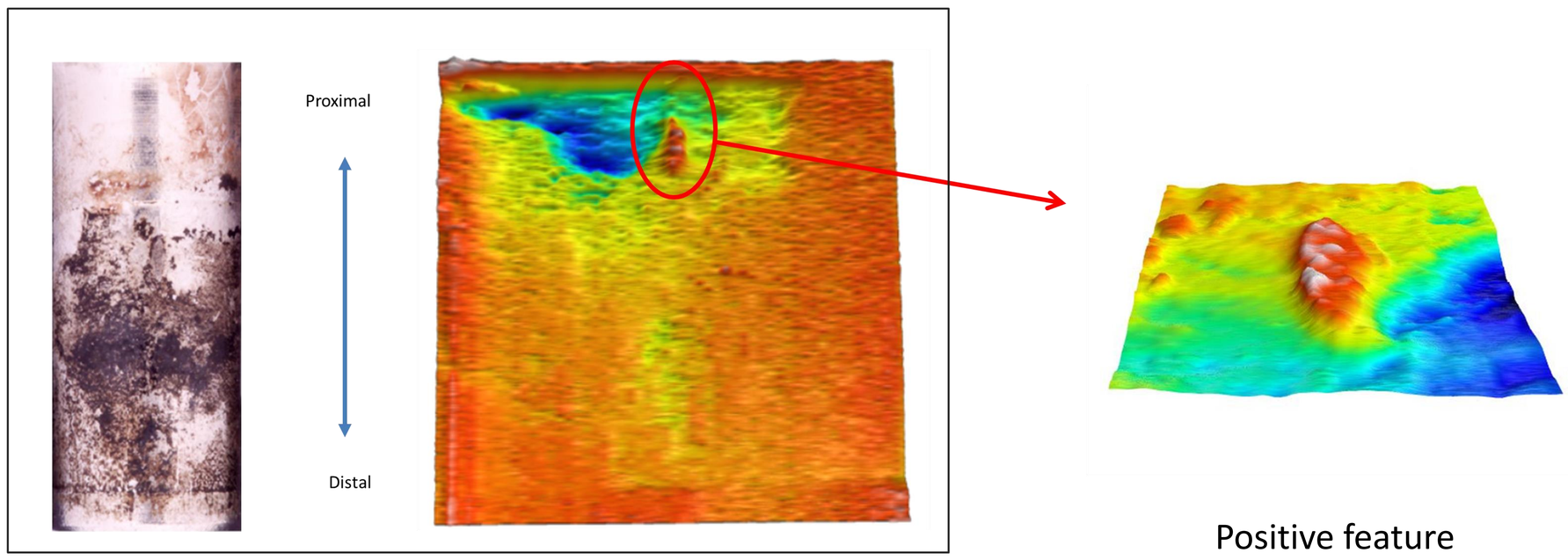
# What we See on the Neck


Deepest areas of damage were found on the inferior proximal and superior distal part of the neck, compatible with bending. Scanning Electron Microscopy with Energy Dispersive Spectroscopy revealed that the surface deposit was chromium orthophosphates indicative of corrosion processes and presence of metal transfer from the stem to the neck.


3-Dimensional map of the lateral round surface of the neck. Deepest area of damage in blue.




3-Dimensional map of the medial round surface of the neck. Deepest area of damage in blue.

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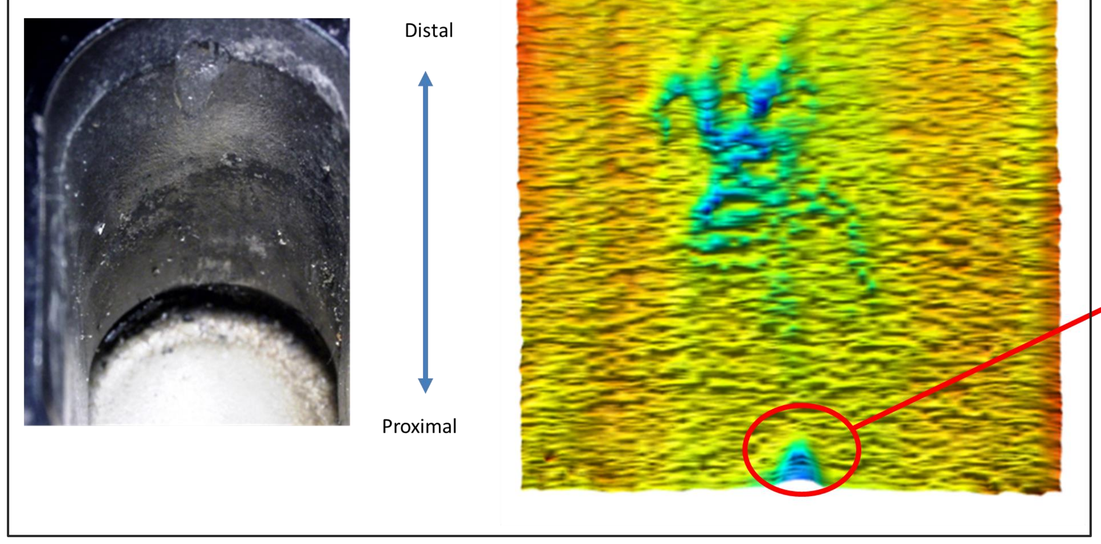
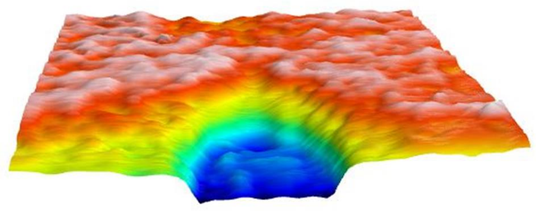
# What we See on the Stem


The symmetry of the patterns found on stem bore tapers confirms micromotion between the parts with subsequent material loss due to a cantilever bending effect which is sufficient to cause adverse tissue reactions.

a'

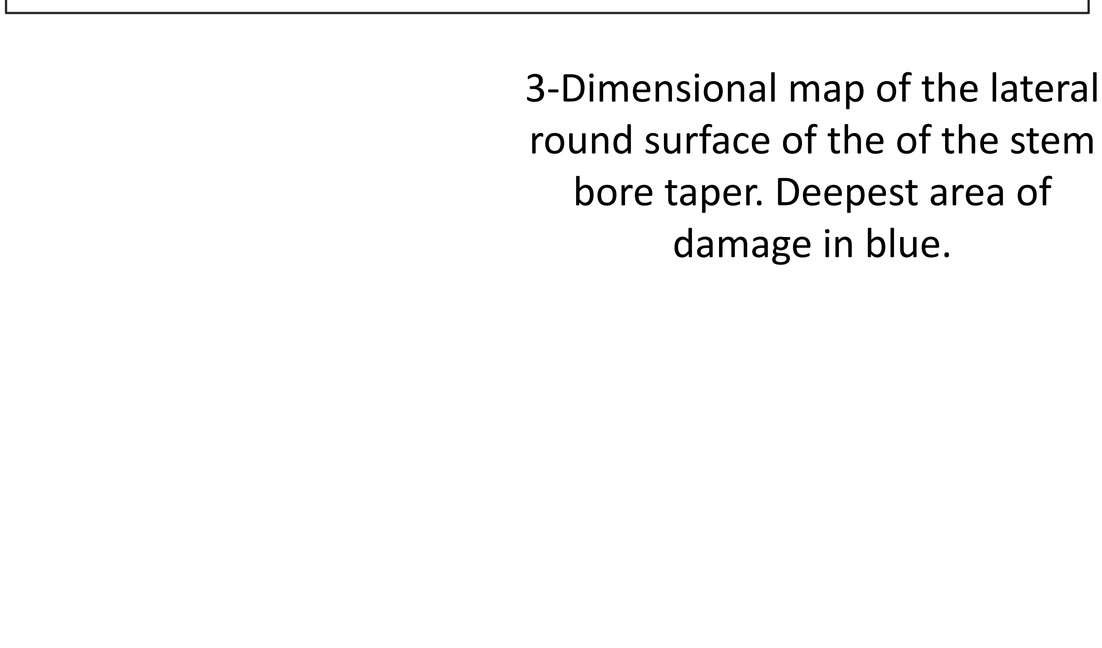


Negative feature

3-Dimensional map of the lateral round surface of the of the stem bore taper. Deepest area of damage in blue.

b'






Negative feature

3-Dimensional map of the medial round surface of the of the stem bore taper. Deepest area of damage in blue.

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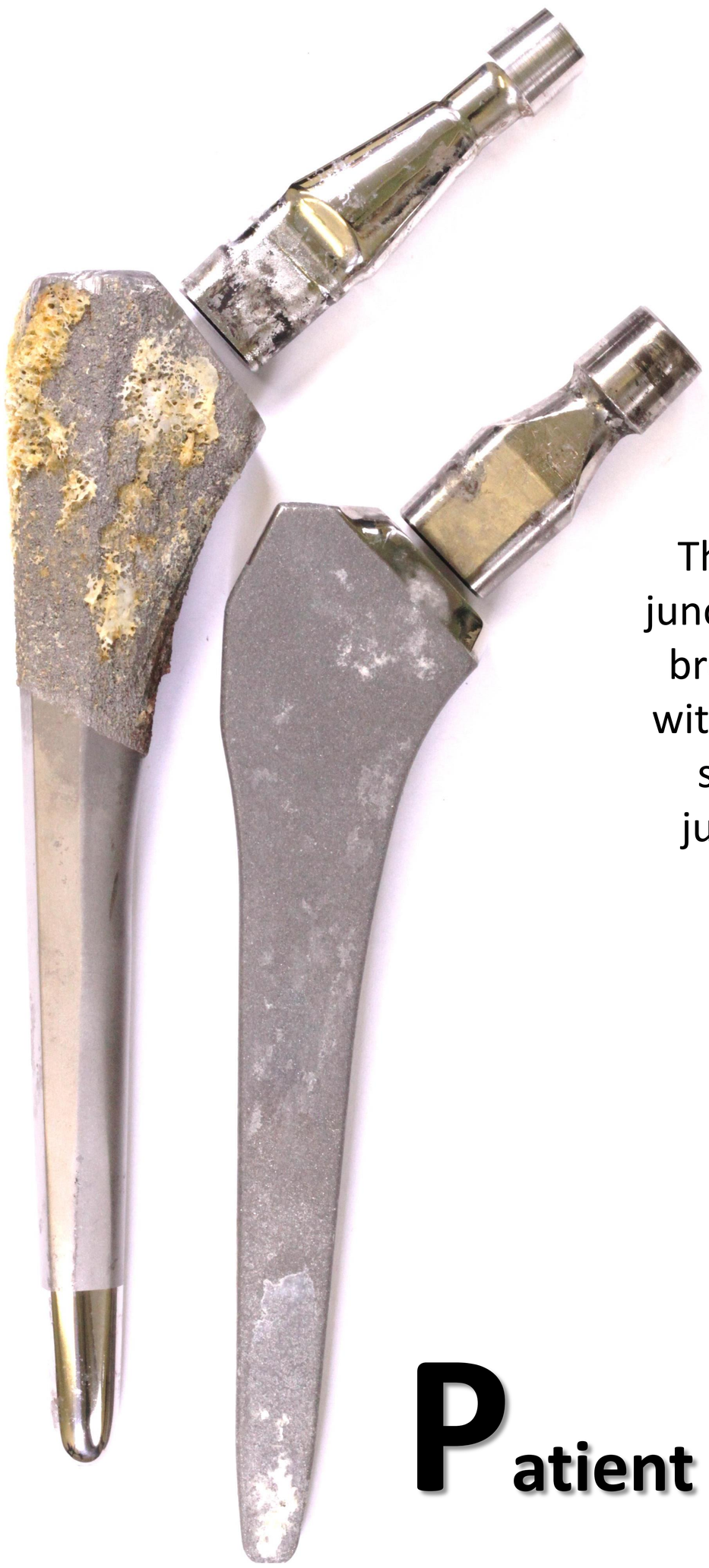
# Influencing Factors

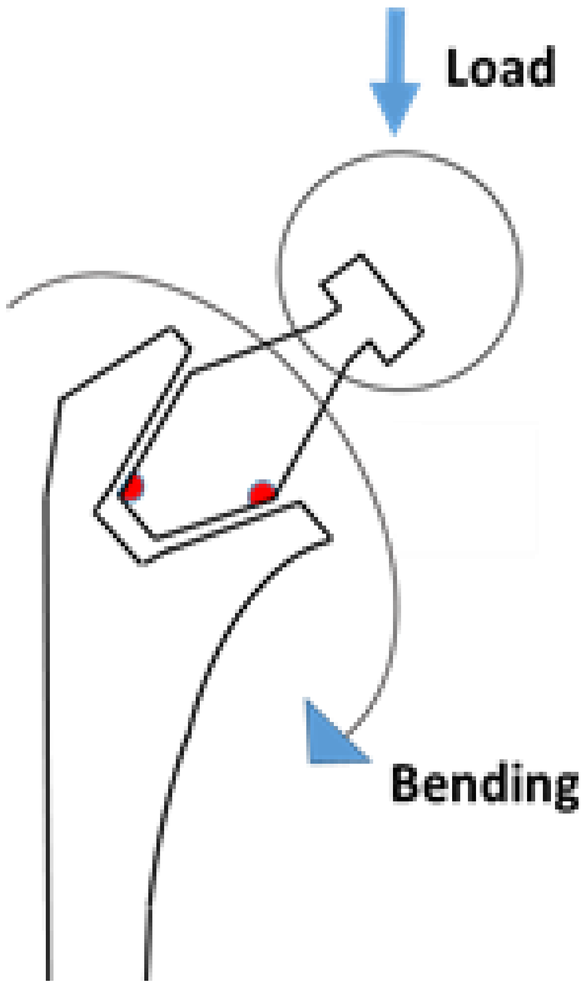
## Surgical

Surgeons should avoid long varus necks if opting for a dual-taper implant.



## Implant

The mismatch of materials at the junction seems to avoid catastrophic breakage of the necks as reported with Ti-Ti junctions [7], however we see corrosion at the neck-stem junction in all the designs having CoCr necks and Ti stems.




## Patient

The severity of surface damage appears to be associated with increasing patient BMI.

***The amount of damage seen on the taper associated with the stem, was severe in almost all cases examined.***

## References

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