Understanding Why Knee Implants Fail

Scientific Exhibit AAOS 2017 Abstract

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Summary

Our multi-disciplinary team of surgeons and engineers will present the mechanisms of failure of knee replacements. We will correlate clinical and imaging data with retrieval analyses in order to identify risk factors.

Introduction

Over 63,335 revisions of total knee arthroplasty (TKA) were performed in the United States in 2015 and this number is projected to grow by 601% between 2005 and 2030 at a cost of more than $2 billion annually.

In this exhibit we will help surgeons understand which surgical, implant and patient factors they should consider in their clinical management. We will present our metrology methods developed using state-of-the-art technology and demonstrate how combining these with high quality imaging of the implant, in situ and when explanted, can help explain failure mechanisms

Methods

Over the past two years, our retrieval centre has collected a large number of retrieved knee components together with detailed clinical data and pre-revision 3D imaging data for each patient. An innovative diagnostic algorithm, based on SPECT/CT imaging techniques, allows us to identify accurately both implant positioning (axial rotation, varus-valgus and extension-flexion angles) and peri-prosthetic bone metabolic activity.

All components are analysed in order to identify the: (1) wear pattern and location of both the articular and backside surfaces of polyethylene inserts, using macroscopic and microscopic techniques and combining Computed Tomography (CT) imaging of retrievals with Coordinate Measure Machine (CMM) metrology methods; (2) wear pattern of contact surfaces of both the femoral and tibial components, using profilometry and high resolution microscopy; (3) oxidation index of all the plastic inserts using Fourier Transform Infrared spectroscopy (FTIR); (4) presence of corrosion in all the metallic components, using scanning electron microscopy (SEM) and Energy-dispersive X-ray spectroscopy (EDX).

Results

Our forensic analysis has enabled us to: (1) identify risk factors for failure of knee implants, (2) provide recommendations and guidelines for surgeons on who, when and how to revise painful knee implants, and (3) to suggest design modifications on current designs based on their present limitations

Conclusions

Failure of knee replacements can be multifactorial influenced by surgical, implant and patient (SIP) factors. We will show the value of the developing and combing state-of-the-art clinical and engineering tools to explain failure mechanisms.

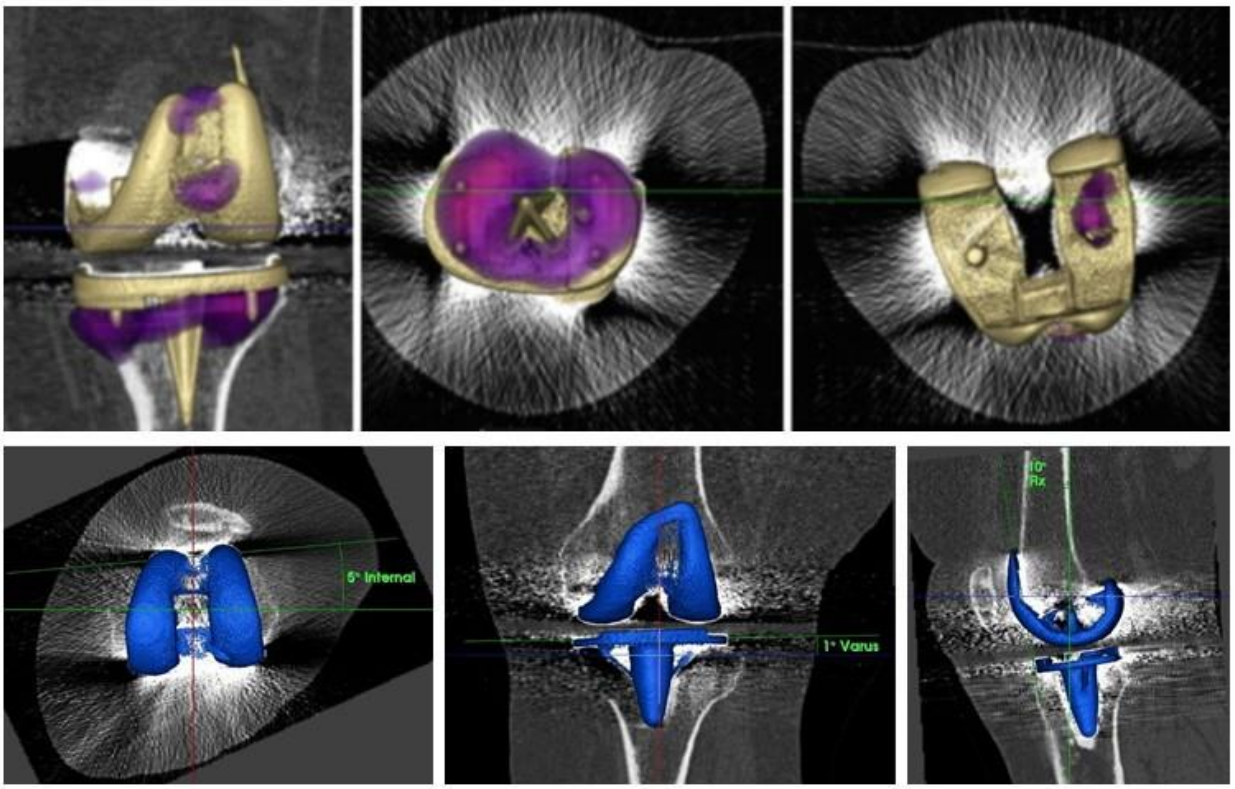

Figure 1 (*upper row*): anterior-posterior, lateral and patellar SPECT/CT imaging indicating loosening of the tibial TKR component; (*lower row*): axial rotation, valgus and flexion angle CT imaging

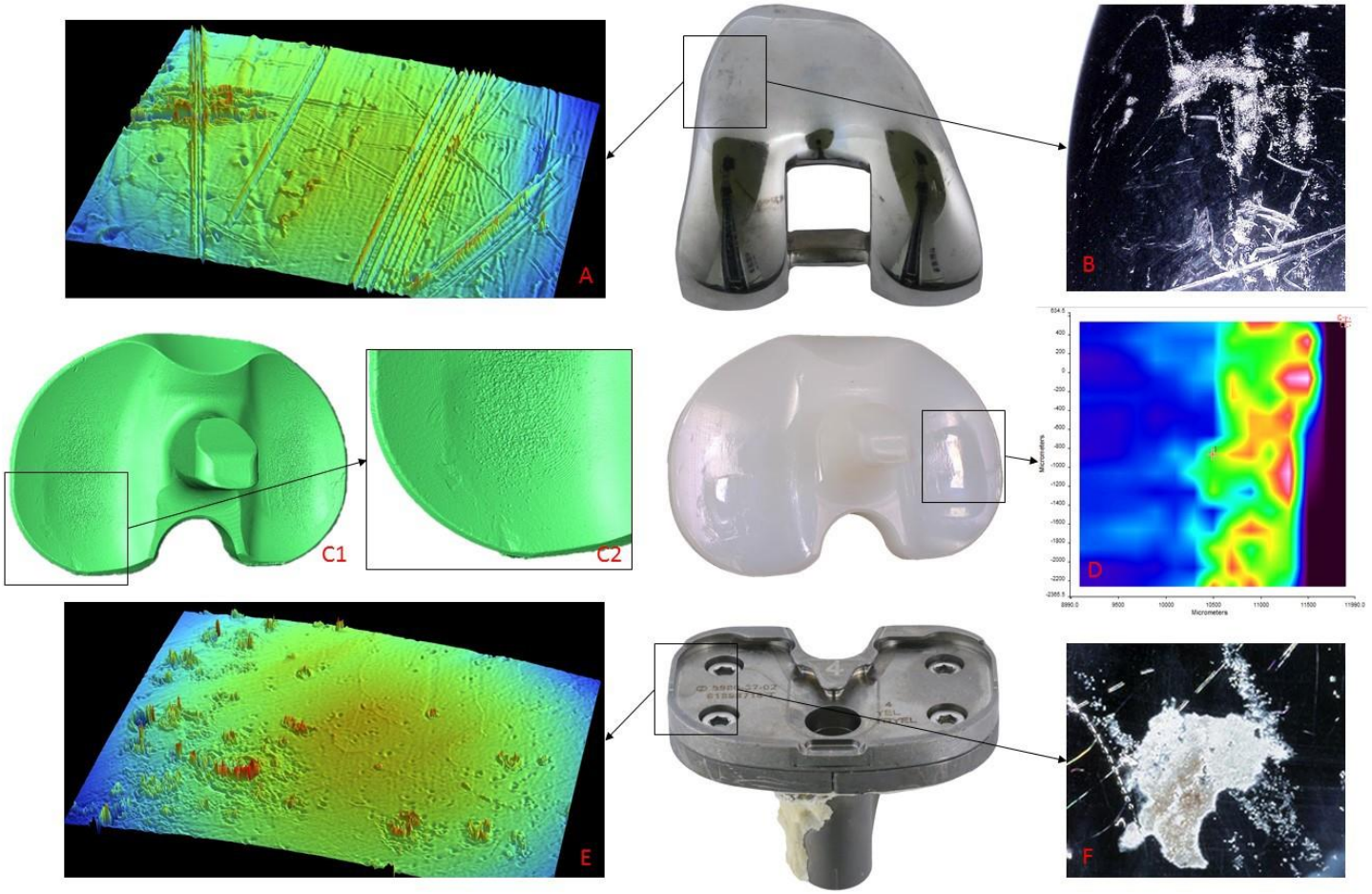

Figure 2 (*upper row*) Examples of retrieval analyses conducted on femoral component: (A) image from profilometer and (B) microscopic inspection;
(*central row*) Examples of analyses conducted on tibial insert: (C1) micro-CT reconstruction and (C2) its magnification (is it possible to see accurately the surface damage) and (D) image from FTIR (a section of polyethylene was scanned. Red colour signifies oxidation)
(*lower row*) Examples of analyses conducted on tibial tray: (E) image from profilometer and (F) corrosion inspection.