



Bioengineering Bulletin

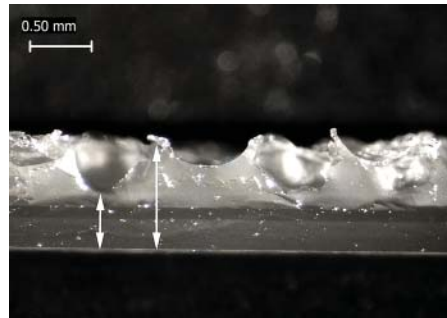
Department of Medical Engineering and Physics Royal Perth Hospital November 2012

Welcome to the 2012 Bulletin. A summary of the work carried out in the Biomaterials Laboratory over the past year is presented. We welcome any feedback or requests for further information.

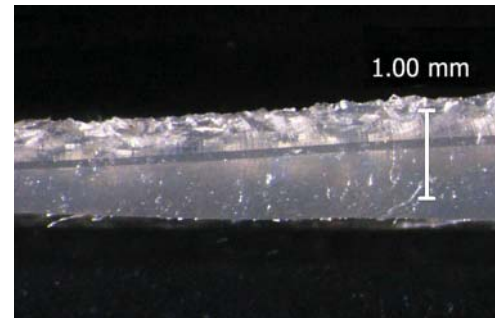
The PIP Silicone Breast Implant Saga: Is Quality Control to Blame?



Ruptured PIP breast implant



Textured shell surface



Shell thickness variation

Poly Implant Prothèse (PIP) silicone breast implants were recalled in Australia in April 2010 following concerns of higher than expected rupture rates and the reported use of unauthorised industrial grade silicone as a filler material. Although subsequent investigations by the NHS expert group and the TGA found that the gel filler material does not pose a threat to human health, the important question of what caused a modern breast implant to have such a

poor outcome remained. Investigations from a materials perspective were urgently required. We obtained 52 explanted PIP devices, both ruptured and intact, from 27 patients and performed a range of mechanical tests and micro/macro-investigations to evaluate possible changes in properties as a result of implantation. The silicone gel and tissue response were also evaluated. New PIP implants were used as the controls.



Elongation tests



Impact tests

RESULTS

- No evidence of shell degradation with time *in situ*.
- Compression testing revealed rupture rates similar to that clinically reported.
- Shell thickness and texture was highly variable with many shells having regions below the minimum manufacturer specified thickness of 0.57mm.
- Potential regions of stress concentration were observed on the smooth inner surfaces and outer textured surfaces of the shell.
- There were inconsistencies in the silicone gel.
- Adverse xanthogranulomatous inflammation was noted in several cases.

CONCLUSIONS

The high incidence of PIP shell rupture appears a result of inadequate quality control with contributory factors being shell thickness variation and manufacturing defects. In a clinical context the fundamental question remains for patients with non-ruptured PIP implants: is not having them removed an acceptable risk?

Whilst this study concurs with other studies that the PIP implant does not necessarily degrade with time, the unpredictable nature of failure is akin to a lottery, where good fortune may dictate longevity. It is recommended patients with PIP implants should consult their specialist for treatment options.

The issue of quality control is not confined to breast implants, we regularly cite quality control as a cause of failure for many types of medical devices. The importance of pre-market and post-market surveillance cannot be overstated. The medical practitioner also has a duty to bring product concerns to the regulatory authority (i.e. TGA). We are always willing to evaluate any medical device that is in question.

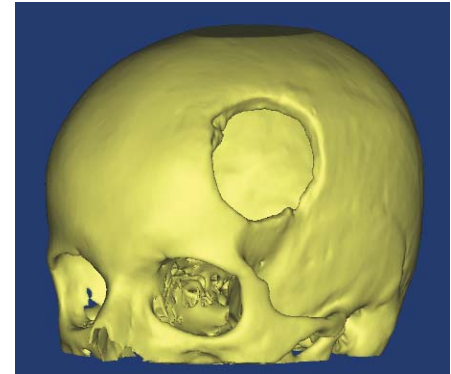
Tissue Engineering Cranioplasty at RPH

Custom titanium cranioplasty is a routine service that has been provided by the Department for more than 10 years. The service has been fully optimised at RPH with advanced computer modelling, hydro formed titanium plates and surface treatment for bone attachment. Titanium cranioplasty is currently the mainstay of treatment for cases where autologous bone is not available, however recent clinical advances have shown the possibility of regenerating tissue in bone deficits using a combination of mesenchymal stromal cells (MSC) and resorbable scaffold materials.



Titanium cranioplasty plates

We have initiated a study to investigate this tissue engineering approach in cranial repair, in conjunction with Cell and Tissue Therapies WA (CTTWA) and a consultant neurosurgeon at RPH. With successful application to the cranial void, the MSC will initiate a cascade of bone formation with the support of the scaffold, which will slowly dissolve and be replaced by the patient's own living bone. This will reduce the risk of infection and bone resorption, leading to a better cosmetic result and obviate any long term consequence of having a synthetic implant material.



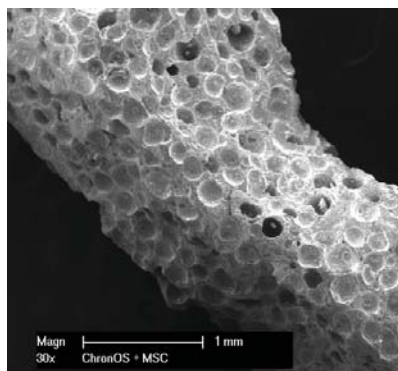
3D model of cranial deficit

Our current custom implant technology will be employed to shape and fit the resorbable scaffold that consists of ceramic granules sandwiched between two polymer plates. MSC will be obtained from bone marrow aspirates of healthy donors, expanded in CTTWA (a TGA licensed manufacturing facility), and combined with the scaffold prior

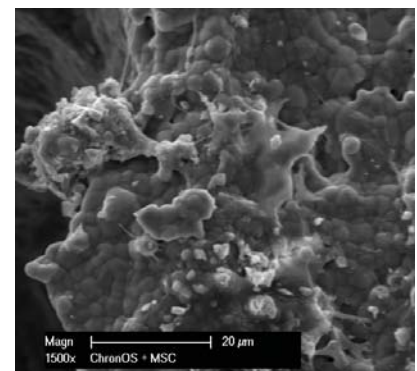
to implantation. We have completed extensive laboratory testing with regards to the materials, both polymer and bioceramic, and the behaviour of the MSC when applied to the scaffold. The results from this development work was recently presented at the 9th World Biomaterials Congress in Chengdu, China.



Resorbable polymer plates



SEM images of a ceramic granule



MSC attached on ceramic surface

This will be the first study carried out in Australia of a cellular tissue engineered therapy to treat a cranial deficit. A phase I clinical trial involving 10 patients is currently planned, for which a Research Infrastructure Support Services grant was successfully obtained. After an exhaustive review process, the study has now been approved by the RPH Human Research Ethics Committee. Patient recruitment is due to commence in early 2013.

Clinical Trial Team

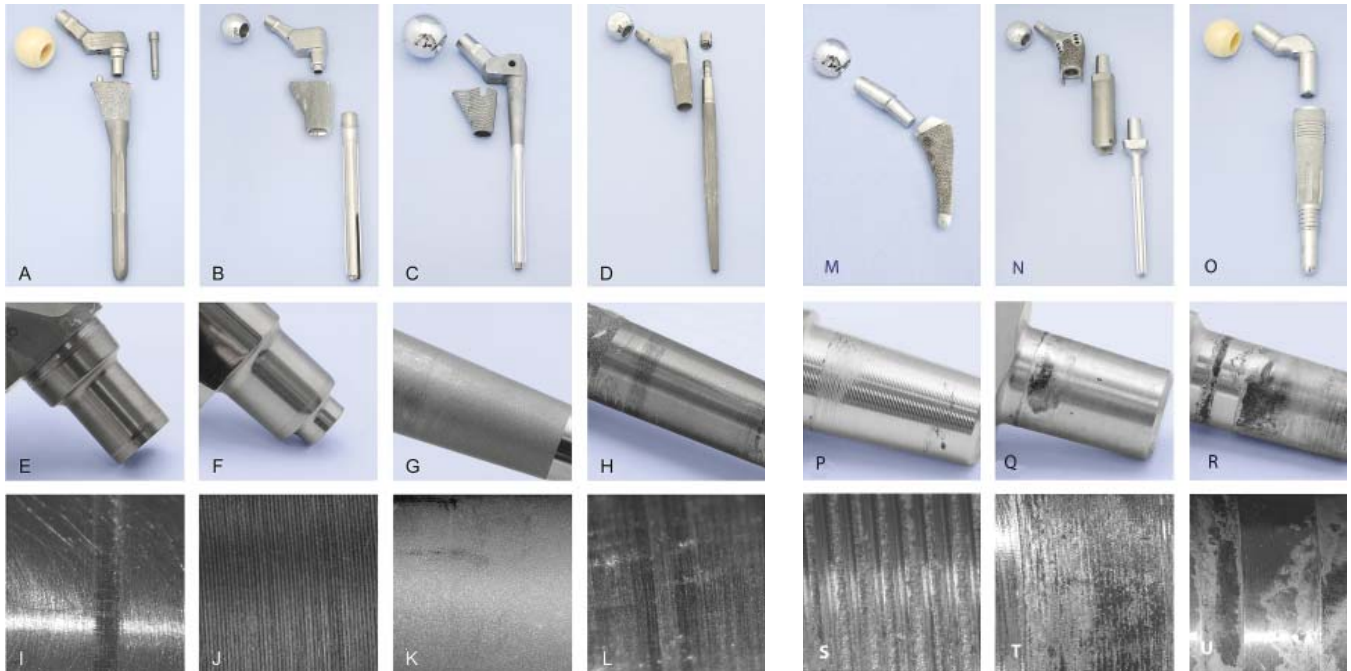
*Dr Stephen Honeybul (Neurosurgery), Dr Alan Kop, Dr David Morrison, Dr Anastasia Nilasaroya (Bioengineering)
Prof Richard Hermann, Dr Marion Sturm, Ms Kathryn Shaw (Cell and Tissue Therapies, WA)*

Proximal Component Modularity: At what cost?

Whilst modular femoral heads have been successfully used in total hip arthroplasty (THA) for decades, a recent innovation is a second 'Morse' taper junction between the neck and the femoral stem. Clinical advantages include intra-operative adjustment of leg length, femoral anteversion, and easier revision, all providing flexibility to the orthopaedic surgeon. Having seen many of these devices revised,

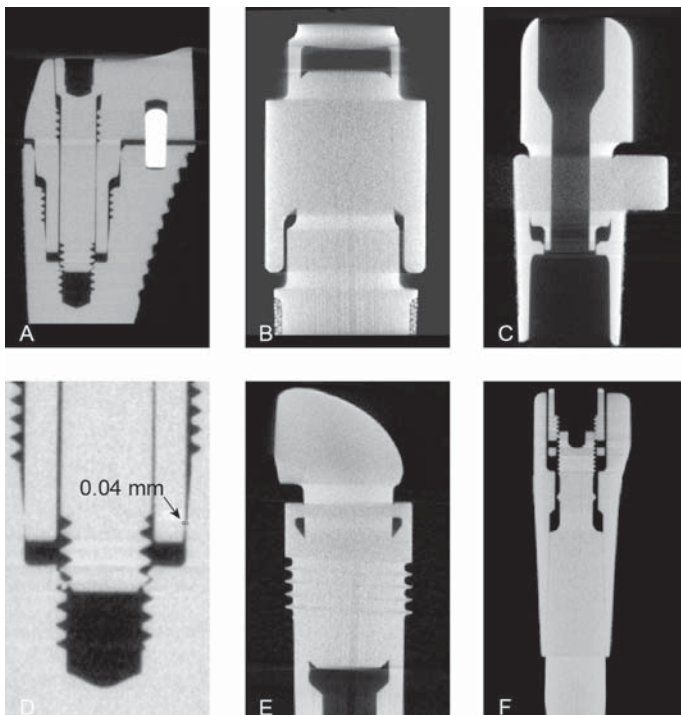
we were interested to see if the introduction of a second modular junction contributed to their revision.

A total of 57 retrieved implants representing seven total hip modular designs (3 cobalt-chromium and 4 titanium alloy) were examined. Macroscopic inspection, microscopy and micro CT were conducted to determine the effects of materials and design.



Ti modular devices (A) Apex (B) M-series (C) S-ROM (D) ZMR
Macroscopic trunnion images (E-H)
Microscopic images (I-L)

Co-Cr modular devices (M) Bionik (N) GMRS (O) Magron
Macroscopic trunnion images (P-R)
Microscopic images (S-U)



Sagittal micro-CT images of proximal sections through the neck-stem junction (A) Apex® (B) GMRS® (C) M-series® (D) Apex® (E) Margron® (F) ZMR®.

Results

- The cobalt-chromium based alloy components showed significant fretting/crevice corrosion of the neck/stem taper.
- The titanium alloy tapers have less corrosion, however, there were several cases of cold welding where disassembly would not be achieved in theatre because of the considerable impact force required, thus necessitating stem revision.
- High serum metal ions were detected.
- 8 cases of metallosis and 2 cases of ALVAL for Co-Cr devices.

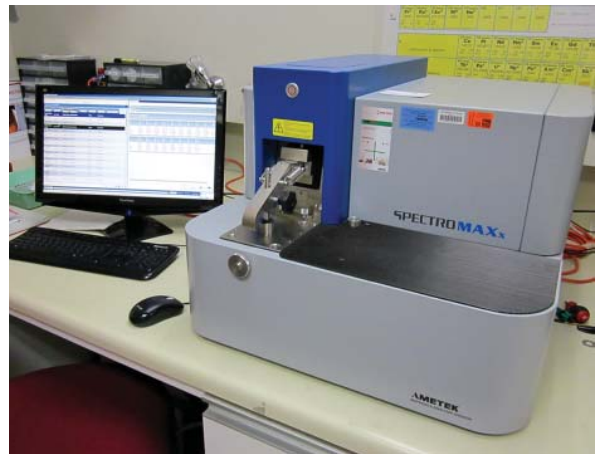
Conclusions Even with modern taper designs and corrosion resistant materials, crevice corrosion, fretting, elevated metal ion and particulate debris are observed. This comes potentially with a significant tissue response including metallosis and ALVAL. Titanium based modular arthroplasty may lessen the degree of degradation, but cold welding of the components may occur, leading to difficulty in revision. Modularity appears to come with a cost.

New Optical Emission Spectrometer

Recent catastrophic failures of metal-on-metal (MoM) hip arthroplasties have highlighted the importance of a newly acquired SpectroMax optical emission spectrometer. Many of the retrieved MoM components have excessive wear and corrosion, whilst the histology of local tissue often show an adverse tissue response including ALVAL. Determining the effects metallurgy and design have on MoM implant performance is the subject of a current study.

The OES spectrometer will enable determination and comparison of the chemical composition of a number of MoM implant components from different manufacturers. Compliance with the relevant implant standards is mandatory, and any non-compliance may point to possible causes of implant failure.

Another application of the OES spectrometer is in the manufacture of custom implants. Bioengineering in conjunction with Technical Services produce a range of custom implants that need to comply with implant standards. Not only can we test for chemical compliance, but by comparing the chemical composition to the electrochemical corrosion profiles of the implant alloy, we can also determine the most suitable material for a given application.



Optical Emission Spectrometer



MoM components after spark tests

Churchill Fellowship

Congratulations to Alan Kop who this year was awarded a Churchill Fellowship in the area of Tissue Engineering. Alan has recently returned from a two months stay in Europe, visiting tissue engineering centres in Italy, Austria, Germany, Belgium, Netherlands and England. Alan hopes to incorporate the knowledge gained from this trip with the ongoing research into applying bioceramic and polymer scaffolds with MSC seeding for treatment of patients with large bony deficits.



Snippets

Retrievals

1. Retrieval Forms

Please ensure you are using our most recent implant retrieval forms (Nov 2011). If you are still using the old forms please contact the lab for replacements.

2. Tissue Analysis

Just an update when sending tissue for metal ion determination. In many cases it may be useful to do further histo work to compliment the metal ion analysis. If this is the case, please send a signed Path West form with the tissue.

Contact us 9224 2573 (lab)
RPH.MEP@health.wa.gov.au

Bioengineering Staff

Trevor Jones
Alan Kop
Eric Swarts
Rob Day
David Morrison
Susan Miller
Cathie Keogh
Anastasia Nilasaroya



Scientific Articles 2011/12

1. Kop, A. Keogh, C. Swarts, E. Proximal Modularity in THA - At What Cost? An Implant Retrieval Study. *Clin Orthop Relat Res.* 2011.
2. Morrison, D. Guy, D. Day, R. Lee, G. Simultaneous Repair of Two Large Cranial Defects using Rapid Prototyping and Custom Computer-Designed Titanium Plates. *J of Eng in Med.* 2011.
3. Taylor P, Day R, Nicholls R, Rasmussen J, Yates P, Stoffel K. The comminuted midshaft clavicle fracture: A biomechanical evaluation of plating methods. *Clin Biomech.* 2011.
4. Swarts, E. Kop, A. Phillips, M. What are the Predictors of Bead Shedding in Porous-Coated Hip and Knee Arthroplasties? An Implant Retrieval Study. *J Arthroplasty.* (in press).
5. Swarts, E. Kop, A. Nilasaroya, A. Keogh, C. Rupture of Poly Implant Prothese (PIP) Silicone Breast Implants: An Implant Retrieval Study. *Plast Reconstr Surg.* (in press).
6. Day, R. Guy, D. Kop, A. Morrison, D. The Royal Perth Hospital Method for the Design and Manufacture of Titanium Cranioplasty Plates. *Br J Oral Maxillofac Surg.* 2012.
7. Wang K, Wu J, Day R, Kirk T. Utilizing Confocal Microscopy to Measure Refractive Index of Articular Cartilage. *J Microscopy.* (in press).
8. Nilasaroya A, Martens P, Whitelock J. Enzymatic degradation of heparin-modified hydrogels and its effect on bioactivity. *Biomaterials.* 2012.