

Impact case study (REF3b)

<p>Institution: University of Southampton</p>
<p>Unit of Assessment: 15 General Engineering</p>
<p>Title of case study: 15-20 Joint Venture: Working in partnership to develop a unique hip replacement treatment</p>
<p>1. Summary of the impact</p> <p>The University of Southampton’s world-leading record in bioengineering continues to deliver significant benefits, resulting from recent research crucial to the development, pre-clinical verification and CE-marking of a revolutionary hip-resurfacing implant. In the wake of growing concerns over some previous implant designs, this work has positively impacted on a wide range of audiences: over 9800 patients have received the new implants with excellent early clinical results at two years’ follow-up. Within 4 years UK PLC benefited with considerable additional turnover [exact figure removed for publication], a majority from abroad, and the technology attracted three years of investment for a start-up company at Southampton Science Park. This award-winning knowledge transferring research has been widely acknowledged as an example of best practice, and has increased appreciation of science and technology further through outreach.</p> <p>2. Underpinning research</p> <p>Reflecting a history of research on implant assessment dating back to the mid-1990s, the University of Southampton’s (UoS) Bioengineering Group has gained a global reputation in the application of novel biomaterials [3.1], pre-clinical testing and computer simulation [3.2] of orthopaedic implants. We have particular expertise in hip resurfacing, working regularly with consultant surgeons throughout Europe and as far away as Australia, and our work has been awarded prizes at international academic conferences. In a Technology Strategy Board Knowledge Transfer Partnership (KTP) (11/06–11/09) with Finsbury Orthopaedics Ltd, a world-leading hip-resurfacing technology company, UoS researchers helped develop a revolutionary hip-replacement implant that is transforming the lives of young patients with osteoarthritis. This research was conducted between 2006 and 2010 by Professor Martin Browne, (then Reader in the Bioengineering Science Research Group, and P.I.), and Dr Alex Dickinson (then Knowledge Transfer Associate / PhD Researcher), under the KTP and Dickinson’s PhD studentship.</p> <p>Compared to a total hip replacement (THR), a resurfacing hip replacement (RHR) is of particular benefit to younger patients. It requires the removal of considerably less bone and presents a lower risk of dislocation, offering a greater chance to return to an active lifestyle. The resurfacing procedure involves a large metal ball (or ‘head’) replacing the bearing surface of the femur, articulating against a thin metal socket (or ‘cup’) in the pelvis. By 2006 RHR was a common procedure. However, there were increasing worries about the rate of early post-operative failures and possible sensitivity reactions to released metal ions, particularly in female patients. Many surgeons stopped performing RHR after metal sensitivity concerns were catastrophically realised in one particular resurfacing design. These failed replacements have come at considerable socioeconomic cost, with adverse tissue reactions seen in nearly 1000 revision surgery patients in 2011, and revision surgery costing on average £12k (NJR 9th Annual Report, and Vanhegan et al 2012 <i>JBJS</i> 94-B(5) p619-623). This reinforced the need for new, more biocompatible implants to be developed, especially for young females.</p> <p>Research at Southampton in collaboration with Finsbury sought to develop and verify a novel hip-resurfacing implant with improved longevity and biocompatibility, exploiting inert ceramic biomaterials that circumvent the possibility of metal sensitivity reactions. This involved the development of a large-diameter, thin-walled, ceramic socket [3.3] and a thin-shell ceramic resurfacing ball [3.4]. State-of-the-art technologies in resurfacing, material screening testing and implant design were reviewed, and rigorous pre-clinical tests and computer simulations were developed to verify the design prior to clinical use.</p>

Impact case study (REF3b)

The University's novel computational analysis techniques enabled the biomechanics of new hip-resurfacing implant designs to be predicted [3.5], while physical testing techniques were developed to verify the implant's strength under loads generated by everyday activity and traumatic events [3.6]. These techniques were essential to turn the company's concepts into validated products. Simulations were previously insufficiently accurate to match clinical observations, and established ISO/British Standard methods are applicable only to conventional implants, so dedicated test methods were required.

The research ultimately led to the development and verification of a set of prototype ceramic resurfacing head and cup implants. These implants, produced from a highly biocompatible material, have predicted improvements in biomechanics through developments in implant fixation and geometry. The verification data generated consequently supported regulatory approval of the implants, resulting in CE-marking.

This project has stimulated additional research projects. UoS and Aurora co-wrote an EU 'Research for the Benefit of SMEs' proposal which funded a 10-partner industrial and academic consortium including Fraunhofer IPA Stuttgart and Gothenburg University (EU FP7, €1.47m total, 2009-2011). This project conducted further hip implant development in which UoS took the research lead, and culminated in cadaver trial surgeries of two further, metal-free prototype implant designs. Following on from this project, UoS is also now leading international research collaboration with IIT-Kharagpur (India) on biomechanical assessment of Hip and Knee Replacements (UKIERI, 2012-14). This has supported three visiting researchers to UoS, generated three joint journal papers, and led to discussions with the Director of Education and Society at the British Council in New Delhi on actions to improve manufacturing of affordable hip and knee implants in India. Finally, these project have seeded internship and postgraduate studentship funding from two industrial partners, Aurora Medical Ltd. (UK TSB KTP, 2012 onwards) and Invibio Biomaterial Solutions (2010 onwards) [Exact values removed for publication].

3. References to the research

Background research examples:

* Asterisks indicate the three references that best indicate the quality of the underpinning research.

[3.1] Taylor, A., Roques, A., **Browne, M.** and New, A. (2005) Evaluation of initial stability of a novel composite stem. *TransOrthResSoc* 30, p1381 (<http://eprints.soton.ac.uk/23431/>)

[3.2]* Jeffers, J., **Browne, M.**, Lennon, A., Prendergast, P. and Taylor, M. (2007) Cement mantle fatigue failure in total hip replacement: experimental and computational testing. *JBiomech* 40(7) p1525-1533 (<http://www.sciencedirect.com/science/article/pii/S0021929006002703>)

Owing to commercial confidentiality, the papers relating specifically to the new implants were published following clinical release:

[3.3] **A Dickinson, M Browne,** J Jeffers, A Taylor, (2008) Pre-Clinical Analysis of an Acetabular Cup with Improved *in-vivo* Stability and Integrity, *Key Engineering Materials*, 369-398, p31-34, (<http://www.scientific.net/KEM.396-398.31>)

[3.4] **A.Dickinson,** A.Taylor, J.Jeffers, **M.Browne** (2010): Performance of the resurfaced hip. Part 2: The influence of prosthesis stem design on remodelling and fracture of the femoral neck, *JEngMedicine* 224, p841-851, (<http://pih.sagepub.com/content/224/7/841.abstract>)

[3.5]* **A.Dickinson,** A.Taylor, **M.Browne** (2012): Implant–bone interface healing and adaptation in resurfacing hip replacement, *CompMethBiomechBiomedEng*, 15(9), p935-947, (<http://www.tandfonline.com/doi/abs/10.1080/10255842.2011.567269>)

[3.6]* **A.Dickinson, M.Browne,** K.Wilson, J.Jeffers, A.Taylor (2011): Pre-clinical evaluation of ceramic femoral head resurfacing prostheses using computational models and mechanical testing, *JEngMedicine* 225, 866-876, (<http://pih.sagepub.com/content/225/9/866.abstract>)

4. Details of the impact

Southampton's research in collaboration with Finsbury Orthopaedics led to the production of two CE-marked orthopaedic implants 'DeltaMotion®' and 'DeltaSurf®', and a portfolio of simulation and test verification data. Southampton's contribution to the collaboration, built upon their internationally leading implant testing and analysis reputation, was the development of dedicated new test methods and computational techniques to evaluate the implants' strength and biomechanics. These techniques were adopted by the company and generated pre-clinical verification evidence, allowing the implants to achieve regulatory approval throughout Europe, in Asia and Australia, and to commence clinical use. Health and socioeconomic impact has followed, described below, with a variety of beneficiaries including patients, healthcare providers, UK PLC and more widely in several UK and EU small/medium enterprises.

Finsbury collaborated solely with the Bioengineering Science Research Group at UoS in this development, and their then-technical director Dr Andy Taylor [5.7] stated that Prof. Browne and Dr Dickinson's work *"produced a technology base which allowed us to realise the innovative design concepts produced at the company, and exploit them commercially. The analysis and testing methods which they developed enabled us to transform concepts into products at the backbone of a multi-million pound business, which were a primary stimulus for the company's purchase."*

Health Impact: The new hip replacement implant system, developed and demonstrated by Southampton's analysis methods, is still unique in the market [5.1] and has benefited young patients with degenerative joint conditions. The first implant, DeltaMotion®, has been in clinical use since November 2008, with over 9800 cups implanted globally, primarily in the EU, Australia and India. The second product, the DeltaSurf® ceramic head, has been successfully trialled in cadavers. Mr Jeremy Latham, orthopaedic surgeon on the DeltaSurf development panel, and user of the DeltaMotion system, provides a continuing surgical link with Prof Browne and Dr Dickinson, and lists DeltaSurf as 'one to watch' [5.6].

The initial DeltaMotion surgeon users published clinical results of 100% cup survival at two years [5.2]. National orthopaedic implant registry data reports good initial clinical results amongst the wider surgeon population (99.1% implant survival at one year [5.3]), an improvement upon the most popular existing total hip replacement implants (97.7-98.8%), in a more demanding group of young, active patients. The design is particularly effective in restoring natural movement in younger patients, as attested to by one of the first UK patients in an email to her surgeon: *"It has made a huge difference to my life. I am now able to do things that I had not been able to do for years. I am back to going to the gym... and I am able to walk for miles, which is something I had not been able to do for some time without being in a lot of pain."* These initial clinical trends suggest that the advances made possible by the research may lower the rate of early post-operative failures for metal sensitivity reactions. If this trend continues, the likelihood of revision surgery – and with it the associated pain, trauma and psychological burden for patients – will be reduced, as will the cost of such procedures for healthcare providers, estimated at over £100 million/year in the UK.

Economic Impact: This research also delivered a range of benefits for Finsbury Orthopaedics Ltd in relation to intellectual property, increased turnover and import sales and the company's eventual sale [5.4]. In Australia, DeltaMotion® achieved 2.5% market share in its first year [5.3], against established systems with a decade of clinical heritage. Design aspects of the implants led to the application for four patents. 9800 implantations are reported in the first four years from clinical release in November 2008 [5.9], which generated considerable sales [exact figure removed for publication], of which over 70% came from abroad. According to Finsbury's MD, Mike Tuke [5.8], DeltaMotion and DeltaSurf strengthened the company's product portfolio and the supporting IP played a major role in Finsbury's survival of the economic downturn and eventual sale, in November 2009, to DePuy International for an undisclosed sum.

DePuy's press releases emphasise that Finsbury's ceramic hip products and patent applications were a key stimulus for the company's purchase [5.4], echoed by Dr Taylor's testimonial [5.7]. The importance of these implant systems and the remaining products in development also led DePuy to invest three years' funding in the spin-out of Aurora Medical Ltd from Finsbury's R&D and design

Impact case study (REF3b)

teams. Aurora employs five full-time-equivalent employees to develop these pipeline products on Southampton Science Park, a start-up business incubator for the University of Southampton.

Dr Paul Naylor, KTP Advisor for the TSB [5.10] reports that this partnership has been widely acknowledged as an example of best practice to help encourage other KTPs. The partnership has featured as a showcase example at several KTP seminars and at the 2009 Collaborate2Innovate event for entrepreneurs, businesses and innovation specialists. The UoS-Aurora partnership won the Engineering Excellence Award and the Best Partnership Award (South East Region) at the KTP Awards 2011 [5.5], and was shortlisted at the 2009 Technology & Innovation Awards (*The Engineer* magazine). Professional recognition came with the BIOLOX Award at the 13th International Symposium for Bioceramics and Alternative Bearings in Joint Arthroplasty.

Helping to inspire a wider appreciation of science and technology, researchers have presented the research at 7 school visit days and several Smallpeice/Dragonfly/HeadStart courses, to over 230 GCSE and A-Level students (15-18 years), and to younger students (13-14 years) in the 'Meet the Scientist' programme. Students picked out the UoS/Finsbury presentations as "really informative" and said that the courses "persuaded me to continue with engineering and look into a career possibly in biomechanics, but definitely engineering" (2010 Smallpeice Trust Biomedical Engineering Course Report to IPEM). The project has also supported four Bioengineering Research Group summer internships for undergraduate students, who have gone on to postgraduate research and industrial engineering careers.

5. Sources to corroborate the impact

Evidence of Health Impact:

[5.1] Product website of DeltaMotion Hip System: system novelty and uniqueness.

<http://www.depuy.com/uk/healthcare-professionals/product-details/deltamotion>

[5.2] Clinical Results: Jenabzadeh R. et al 2012, DeltaMotion Hip System – Two Year Outcomes, 25th Annual ISTA Congress, Sydney

[5.3] Clinical Results: AOA National Joint Replacement Registry Annual Report 2012

<https://aoanjrr.dmac.adelaide.edu.au/annual-reports-2012> p47, 49, 89 and 90 (highlighted)

Evidence of Economic Impact:

[5.4] News reports and Press Releases on Finsbury Sale: centrality of ceramic hip implant technologies to motivation for purchase by DePuy

<http://www.depuy.com/healthcare-professionals/news/depuy-orthopaedics-inc-acquires-finsbury-orthopaedics-limited-depuy>

[5.5] News report on KTP Awards, to University of Southampton and Aurora Medical Ltd.

<http://www.ktponline.org.uk/2011awards/> &

http://www.southampton.ac.uk/business/ktp_showcase/ktp_awards_2011.pdf p12-13

End-Users and Beneficiaries to Corroborate Impact Claims (contact details attached):

[5.6] End User: Member of the Orthopaedic Community

Mr Jeremy Latham, consultant surgeon:

<http://www.lathamconsultancy.com/blog/tag/resurfacing/>

[5.7,5.8] Beneficiaries: Industrial Recipients of the Technology Developed:

Dr Andy Taylor, then Technical Director at Finsbury Orthopaedics Ltd., who coordinated implantation of the first ~4000 DeltaMotions, now MD of Aurora Medical Ltd, and Mr Mike Tuke, then MD of Finsbury Orthopaedics Ltd., now director of MatOrtho Ltd.

[5.9] [Anonymised for publication]

DeltaMotion sales and implantation figures.

[5.10] Referee: Knowledge Transfer Partnership Advisor, UK Technology Strategy Board

Dr Paul Naylor, KTP advisor, monitored company-university partnership progress.