The University of Nottingham
UNITED KINGDOM · CHINA · MALAYSIA

Loughborough University

EPSRC Re-Distributed Manufacturing in Healthcare Network Feasibility Study:

3D Bioprinting: Commercialising Personalised ATMP/Device Combination Products

Rationale

Developments in bioprinting capabilities in recent years have made it possible to manufacture customised implants tailored to a specific patient, containing autologous patient cells. Bioprinting offers the ability to co-print a polymer framework (for fidelity and mechanical properties) together with a cell-laden hydrogel (for tissue regeneration). Patient data is used to generate 3D models that are adapted to the treatment plan for an individual patient. These 3D models are used by the bioprinter software to manufacture implants with the required geometry. The relatively low cost and simplicity of bioprinters make them an ideal candidate for redistributed manufacture (RDM). Currently, no businesses exist that bioprint Advanced Therapy Medicinal Products (ATMPs) in a hospital on a commercial basis. This project set out to establish the barriers to feasibility of such commercialisation. For example, existing regulatory frameworks have not yet addressed the differences between products (or their structural parts) manufactured by bioprinting technology and those manufactured by conventional, more craft-based methods.

Method and research conducted

Interviews and workshops were held with a variety of experts including clinicians, equipment suppliers and tissue engineering researchers. These interviews enabled product scenarios (focusing on different types of tissue engineering) to be identified along with possible operational business scenarios (alternative approaches to production ranging from centralised to redistributed). The interviews also enabled the tasks involved in the manufacture of bioprinted ATMPs to be determined in detail.

Data gathered through interviews was used to create IDEF0 maps for bioprinting ATMPs. These maps considered a large number of factors including: who is involved in each modelled activity; where each activity is located; which regulatory directives are applicable; what information or documents pass between activities; what physical material is transformed during an activity and how that material passes between activities; and personnel and equipment/facilities that are involved in each activity. The maps also act as frameworks for future business development.

Main findings and further work

The project identified several barriers to the feasibility of RDM bioprinting currently from aspects relating to commercialisation, technological capability, the regulatory framework and hospital adoption. However, many of these barriers also apply to centralised manufacturing (not currently undertaken).

In particular, the continuous development and improvement of bioprinting technology presents a major challenge to regulators. This may be addressed by improving the ability of the regulations to adapt. Furthermore, a recurring theme of the interviews with specialists was the need for improvements to the technical capabilities of bioprinters, particularly to improve repeatability (physical structure repeatability, print job success rate, call viability repeatability, etc.). Software and modelling capabilities were particularly important according to the bioprinter manufacturer. Commercialisation feasibility is currently limited by the technological readiness (for bioprinting and cellular therapy) and regulatory requirements (which must be driven by technological developments rather than vice versa).

Future studies should assess commercial feasibility in the near future (<10 years), once the technological capabilities are more clearly established. It is important that hospitals, universities and businesses collaborate to ensure the interests of all parties combine to realise future developments.

People involved

The research team primarily consisted of Andrew Gleadall and Joel Segal from the University of Nottingham (Manufacturing and Process Technologies division) and Paul Hourd and Nick Medcalf from Loughborough University (Centre for Biological Engineering). Expertise of team members included the manufacturing route from patient data to clinical product, computer modelling for the design and optimisation of tissue engineering products, research and manufacture of advanced therapeutics in industry, and regulatory/translational science. Additionally, the project benefited from regulatory affairs consultancy provided by Alison Wilson of CellData Services. This was invaluable in guiding the approach and ensuring a strong focus on the regulatory impact of the project.