The New World of 3D Medical Printing

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3D medical printing has the potential to completely revolutionize how we practice medicine. Everything from fingers to teeth to heart valves could potentially be printed using a patient's very own cells. Experts predict within decades 3D printing will change the entire delivery of healthcare as we know it.

3D medical printing, known as additive manufacturing, is similar to printing on a regular desktop printer except that one prints the same sheet over and over again, building layer upon layer and finally creating the finished product. These bioprinters use "bio-ink", multi-cellular building blocks to lay down a structure for the tissue to form. Eventually, researchers hope to be able to build organs for transplant. Progressing to the next step of reproducing intricate micro-architecture of extracellular matrix and several cell types with adequate resolution to create a functioning organ is the main challenge (Murphy, 2014). Another challenge is to alter technologies originally intended to print molten plastics and metals to printing sensitive biological materials. Although developing functional organs may be decades off researchers are advancing bioprinting for other uses now, including for prosthetics, implants, organ transplants and pharmaceuticals.

One area of 3D uses is with prothestics. A challenge with prosthetics is to get them to fit perfectly, too tight and it becomes painfully uncomfortable, too loose and the limb will fall off. Professor Chuck Zhang at Georgia Institute of Technology is tackling this problem with military veterans. Zhang and his team are working on creating a 3D printed prosthetic socket that will adapt to the bodies' naturally changing fluid levels. Allowing the prosthetic to customize to a patient's individual needs.

Implantable 3D printed pieces are being used in patients now to save lives. In 2012, a baby was born with a birth defect causing a weak trachea meaning that the babies windpipe collapses, cutting off the ability to breath. Doctors hooked the baby up to a ventilator but the airway was not getting stronger; the baby was going to die. A 3D tracheal splint was custom fit out of polycaprolactone to hold the baby's airway open. The dissolvable implant was absorbed once the trachea was strong enough to stay open on its own (Zopf, 2013).

Not only are metals and plastics being printed in 3D, now scientists are using human cells in efforts to print living tissue for organ transplant patients. If patients' own cells were used, patients would not die waiting in line for an organ donor nor would their immune systems reject the transplanted organs. One method to print an organ is to start by creating a plastic mold of the organ that can be covered with human cells. Another method is that a printer can print out human cells in a collagen-based gel that will hold itself together. Once this step is complete the cells will grow for several weeks. The tissue would be able to grow once transplanted inside the patient requiring no need for surgeries as the patient grows.

Pharmaceutical companies are sinking funds into bioprinting because of the financial savings during clinical drug testing. Medical researchers from pharmaceutical companies in the past have tested drugs on 2D cell cultures which do not reflect human tissue as accurately as 3D printed tissue. More precise results can be determined earlier from the 3D tissue, allowing pharmaceutical companies to halt funding into failed drugs. The largest part of pharmaceutical companies' budgets comes from clinical trials so more precise, faster research will help avoid wasted costs.

Regenerative medicine in 3D printing has multitudes of benefits. The time of additive manufacturing in the medical field is upon us now, lives are being drastically improved from this technology.

References

Fuller, J. A model of Garrett's trachea. Retrieved from: http://www.npr.org/blogs/health/2014/03/17/289042381/doctors-use-3-d-printing-to-help-a-baby-breathe

Murphy, S. V. et al. (2014). 3D bioprinting of tissues and organs. *Nature Biotechnology, 32*, 773-785

Zopf, D. A., Hollister, S.J., Nelson M. E., Ohye, R. G.& Green, G. E. (2013). Bioresorbable Airway Splint Created with a Three-Di mensional Printer. *New England Journal of Medicine, 368*(21), 2043-045.