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3D bioprinting of soft tissue for reconstructive plastic surgery

Reconstructive plastic surgery often lacks autologous tissue and hence, extensive surgical procedures or synthetic alternatives play a major role for restoring shape and function after cancer surgery, injuries or congenital defects.

Synthetic and prosthetic replacement materials are associated with numerous problems.

i. Foreign materials are designed to have excellent mechanical properties but do not adequately replicate the functional properties of biological tissues.
ii. Foreign materials never truly integrate, leaving a border at the interface of the material and the surrounding tissue, presenting an eternal challenge.
iii. Foreign materials are susceptible to infections. Such infections are devastating and often require replacement surgery of the reconstructed body part or implant removal.
iv. Foreign materials can pose long-term risks, e.g. development of Breast Implant-Associated Anaplastic Large Cell Lymphoma.

These problems can potentially be avoided using autologous-based components. The most obvious example is autologous, instead of prosthesis-based, reconstruction of the breast after surgery for breast cancer.

3D bioprinting has emerged as a new modality to produce autologous human tissues. Our overall strategy has been to keep the processes of harvesting tissue, bioink preparation and printing as simple as possible to avoid unnecessary regulatory obstacles for taking the technique from the bench to the bedside. We work with tissues rather than organs, use approved materials for the bioink and avoid adding stem cells or cultured cells. In particular, printing with microfractured adipose tissue, harvested by liposuction and mechanically processed has shown promising results. Spontaneous vascularization from the host animal has been the key for survival of the 3D bioprinted tissue in vivo and this can be demonstrated histologically, in small animal MRI and in small animal ^{18}FGD PET. The 3D printing structure is also of importance and by printing gridded constructs, host vessels can penetrate the implanted construct through the printed channels. By scaling up the construct size we determine the maximal size that would be possible to implant. To date, a 40x20 mm half sphere of porcine adipose tissue has been printed and implanted. Its fate remains to be seen.

After a 10 year period of experimental work we are ready to take 3D bioprinted adipose tissue into the future with a first-in-human testing and all necessary permits from relevant authorities are at hand.