The effect of geometry on three-dimensional tissue growth

Abstract

Tissue formation is determined by uncountable biochemical signals between cells; in addition, physical parameters have been shown to exhibit significant effects on the level of the single cell. Beyond the cell, however, there is still no quantitative understanding of how geometry affects tissue growth, which is of much significance for bone healing and tissue engineering. In this paper, it is shown that the local growth rate of tissue formed by osteoblasts is strongly influenced by the geometrical features of channels in an artificial three-dimensional matrix. Curvature-driven effects and mechanical forces within the tissue may explain the growth patterns as demonstrated by numerical simulation and confocal laser scanning microscopy. This implies that cells within the tissue surface are able to sense and react to radii of curvature much larger than the size of the cells themselves. This has important implications towards the understanding of bone remodelling and defect healing as well as towards scaffold design in bone tissue engineering.

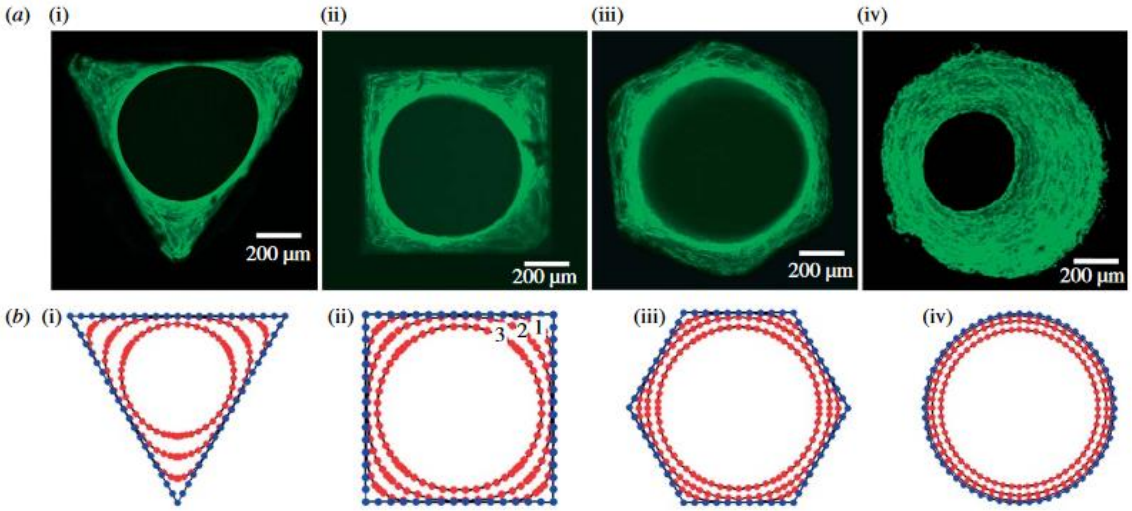

Figure 1. (*a*) New tissue formed in three-dimensional matrix channels. Actin stress fibres are stained with phalloidin-FITC and visualized under a confocal laser scanning microscope. Here, the tissue formation is shown (i–iii) after 21 days and (iv) after 30 days of cell culture in the channels of a (i) triangular, (ii) square, (iii) hexagonal and (iv) round shape introduced into a HA plate *in vitro*. (*b*) Numerical simulation of tissue formation within channels of various shapes: (i) triangular, (ii) square, (iii) hexagonal and (iv) round. The lines (early time point 1, ongoing times 2 and 3) mark the simulated development of tissue formation due to ongoing culture time, which corresponds closely to the observed development of new tissue formation *in vitro*.